Appendix I4

Biological Opinion & Biological Assessment

Part 1 of 4

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From:	LeBlanc, Darren
To:	Meghan Pawlowski
Cc:	Mike Chavez; Jodi Bechtel
Subject:	Re: US 281
Date:	Wednesday, April 22, 2015 1:25:56 PM

H Meghan. Your correction to the amount of impervious cover, 118 acres instead of 98 acres, as described in the BA for with the US 281 project is noted. We have evaluated the change and believe there is no need to modify the Biological Opinion previously issued by the Service since it does not alter the effects of the project, the covered species, or the amount and types of incidental take that have been authorized.

Please let me know if you have any questions or need further assistance on this issue. Thanks.

On Thu, Apr 16, 2015 at 4:55 PM, Meghan Pawlowski <Meghan.Pawlowski@txdot.gov> wrote:

> Hi Darren,
>
> As discussed a few minutes ago, in reviewing the Final EIS for the US 281 project (Consultation # 02ETAU00-2015-F-0031) we noticed a discrepancy in the amount of impervious cover that was listed in BA and subsequent BO, and what is presented in the FEIS. The BA/BO reported a total of 98 acres of impervious cover being added under the proposed project. The FEIS (which reports the accurate value) is reporting 118 acres of impervious covering being added by the preferred alternative. There is an increase of 20 acres of impervious cover from what was consulted on and what will be occurring on the ground. TxDOT would like to emphasize that the calculations for TSS and all of the appropriate water quality BMPs were crafted using the 118 acres and not the 98 acres. The 98 acres of impervious cover was a typo in the BA and did not affect any of the engineering calculations for the actual project.
>
> As unfortunate as this typo is, the amount of impervious cover was not directly tied to the amount of take allotted under the BO. The BO based its take assessment on several factors but was heavily tied to the amount of excavation across the project and not the amount of impervious cover added to the landscape.
>
> Please let me know how best to rectify this discrepancy so that we can incorporate the Service’s response into our Final EIS file. Thanks again for your help!
>
> -Meghan
>
> Talk. Text. Crash.

--
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March 11, 2015

Mr. Carlos Swonke
Texas Department of Transportation
Environmental Affairs Division
125 East 11th Street
Austin, Texas 78701-2483

Consultation Number: 02ETAU00-2015-F-0031

RE: CSJs 0253-04-138 & 0253-04-146

Dear Mr. Swonke:

This document transmits the US Fish and Wildlife Service's (Service) biological opinion (BO), based on our review of the Texas Department of Transportation's (TxDOT) proposed improvements to US 281, from Loop 1604 north to the Comal County line, in San Antonio, Bexar County, Texas. In this document we evaluate the effects of the proposed action on the endangered Madla's Cave meshweaver *Cicurina madla* and two unnamed troglobitic beetles, *Rhadine infernalis* and *Rhadine exilis,* in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). TxDOT's final Biological Assessment (BA) and request for formal consultation was received on January 6, 2015.

Section 7 of the Act requires that all Federal agencies consult with the Service to ensure that the actions authorized, funded, or carried out by such agencies do not jeopardize the continued existence of any threatened or endangered species or adversely modify or destroy designated critical habitat of such species. The Federal Highway Administration (FHWA) assigned responsibility for compliance with the National Environmental Policy Act (NEPA) and all federal resource agency consultations, including section 7 formal consultations, to TxDOT in a Memorandum of Understanding (MOU) dated December 16, 2014 (23 U.S.C. 327). Therefore, TxDOT is the Federal agency associated with this proposed project.

This BO is based on information provided in TxDOT's September 5, 2014 informal consultation request, the final BA, dated January 5, 2015, information in the April 2013 draft Environmental Impact Statement (dEIS), field biological investigation reports, interagency meetings and discussions, Service files and other sources of information. A complete administrative record of this consultation is on file in the Austin Ecological Services Field Office (AUESFO).

TxDOT has determined this project "may affect, and is likely to adversely affect" *C. madla, R. exilis,* and *R. infernalis*. Critical habitat (CH) has been designated for these species, but only a small portion of one CH Unit (CHU) occurs within the proposed project action area. This BO does not rely on the regulatory definition of "destruction or adverse modification" of CH in 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the Act to complete the following analysis with respect to CH.

The Service concurred with a "may affect, not likely to adversely affect" determination for the golden-cheeked warbler (*Dendroica [=Setophaga] chrysoparia*) (GCW) in a letter dated January 7, 2015. TxDOT has also determined that the project would result in "no effect" to 16 other federally protected species and 5 candidate species (**Table 1**).

Table 1. Federally listed and candidate species that may occur within Bexar County and which TxDOT has determined would not be adversely affected by the proposed project.

Common Name (Scientific Name)	Federal Status	Effect Call Justification
Karst Invertebrates		
Texas wild rice (*Zizania texana*)	Endangered	The project is outside of the known range for this species.
Helotes mold beetle (*Batrisodes venyivi*)	Endangered	The project area is outside of the known range for this species.
Cokendolpher Cave harvestman (*Texella cokendolpheri*)	Endangered	The project area is outside of the known range for this species.
Government Canyon Bat Cave meshweaver (*Cicurina vespera*)	Endangered	The project area is outside of the known range for this species.
Robber Baron Cave meshweaver (*Cicurina baronia*)	Endangered	The project area is outside of the known range for this species.
Bracken bat cave meshweaver (Cicurina venii)	Endangered	The project area is outside of the known range for this species.
Government Canyon Bat Cave spider (*Neoloptoneta microps*)	Endangered	The project area is outside of the known range for this species.
Black-capped Vireo (*Vireo atricapilla*)	Endangered	No suitable habitat within the project area.
Peck's Cave amphipod (*Stygobromus pecki*)	Endangered	The project area is outside of the known range for this species.

Common Name (Scientific Name)	Federal Status	Effect Call Justification
Comal Springs dryopid beetle (*Stygoparnus comalensis*)	Endangered	The project area is outside of the known range for this species.
Comal Springs riffle beetle (*Heterelmis comalensis*)	Endangered	The project area is outside of the known range for this species.
San Marcos salamander (*Eurycea nana*)	Threatened	The project area is outside of the known range for this species.
Texas blind salamander (*Eurycea rathbuni*)	Endangered	The project area is outside of the known range for this species.
Interior Least Tern (*Sterna antillarum athalassos*)	Endangered	No suitable habitat within the project area.
Whooping Crane (*Grus americana*)	Endangered	No suitable migratory stopover habitat within the project area.
Fountain darter (*Etheostoma fonticola*)	Endangered	The project area is outside of the known range for this species.
Sprague's pipit (*Anthus spragueii*)	Candidate	The project area is outside of the known range for this species.
Bracted twistflower (*Streptanthus bracteatus*)	Candidate	Habitat for this species occurs in the project area but no specimens were observed during on-site habitat assessments.
Golden orb (*Quadrula aurea*)	Candidate	The project area is outside of the known range for this species.
Texas fatmucket (*Lampsilis bracteata*)	Candidate	The project area is outside of the known range for this species.
Texas pimpleback (*Quadrula petrina*)	Candidate	The project area is outside of the known range for this species.

Consultation History

The consultation history for this project is listed below.

March 24, 2009:	Meeting between the Alamo Regional Mobility Authority (ARMA), Blanton and Associates, TxDOT, and the Service to discuss the federally listed species that may be affected by the proposed project. The Service identified the GCW as potentially present in the area of the project and discussed habitat assessment methodology. The Service also identified the need for karst feature surveys to determine if any of the nine listed karst invertebrates in Bexar County would be affected.
April 10, 2009:	Site visit to the US 281 project area to confirm GCW habitat assessment.
January 22, 2010:	Meeting between ARMA, FHWA, TxDOT, and the Service to discuss the results of the bird and karst surveys. Two years of surveys for the GCW and black-capped vireo (BCV) resulted in no observed occurrences.
September 15, 2010:	US 281 EIS coordination meeting held in San Antonio to discuss listed species surveys, consultation initiation, dEIS status, karst CHU review, and next steps.
October 18, 2010:	Letter submitted by the ARMA to the Service requesting concurrence for two years of negative findings on GCW surveys would be sufficient to demonstrate absence.
March 1, 2011:	US 281 EIS coordination meeting held in San Antonio to discuss listed species surveys, BE and dEIS schedule and status, remaining species surveys, and next steps.
May 11, 2011:	USFWS response letter to ARMA concurring that two years of negative GCW surveys were adequate is construction were initiated within three years of previous surveys. If a longer period of time ensued, at least one additional year of negative GCW survey would be required.
April 2013:	TxDOT announced the availability of the dEIS and requested the Service's review of the document.
May 2013:	The Service's Albuquerque Regional Office (R2) provided an email to TxDOT with Service comments on the dEIS.
September 5, 2014:	TxDOT submitted an informal consultation request and Biological Evaluation (BE) to the Service for the project. TxDOT requested

concurrence that the proposed project "may affect, but was not likely to adversely affect" *C madla, R. exilis, R. infernalis* and the GCW.

September 23, 2014: Site visit made by TxDOT, Zara Environmental, and Service biologists to examine the CHU 12, located adjacent to the project right-of-way (ROW), and areas of the existing ROW where excavation would be needed for construction of the new road. The site visit was followed up by a meeting between FHWA, TxDOT, the environmental consultants, and the Service to discuss the project and the need for additional justification for the "may affect, not likely to adversely affect" determination for karst species. The Service recommended FHWA initiate formal consultation if subsurface excavation in Karst Zones 1 and 2 could not be avoided.

December 2, 2014: TxDOT submitted a draft BA to the Service for review.

December 5, 2014: Meeting between TxDOT and the Service to discuss aspects of the BA which needed revision. In particular, TxDOT's proposed conservation measures were discussed.

December 12, 2014: Telephone discussion between TxDOT and the Service to go over revised proposed conservation measures.

January 6, 2015: TxDOT submitted the final BA with requested modifications and a letter requesting initiation of formal section 7 consultation under the Act.

January 7, 2015: The Service submitted a letter to TxDOT concurring with their "may affect, not likely to adversely affect" determination for the GCW and initiating formal consultation on three listed karst invertebrate species.

February 5, 2015: The Service provided TxDOT with a draft BO for review and comment.

February 20, 2015: TxDOT provided comments on the draft BO. The Service made minor changes to the document and proceeded to finalize the BO.

BIOLOGICAL OPINION

Description of Proposed Action

The proposed project includes improvements to US 281, within the city of San Antonio, along a 7.3 mile portion of the roadway, from Loop 1604 north to the Comal County line just north of Borgfeld Drive, in northern Bexar County, Texas (**Figure 1**). The proposed project is divided into two portions, with each portion having a different roadway configuration. The southern portion extends from Loop 1604 to Stone Oak Parkway, and the northern portion extends from Stone Oak Parkway to 0.6 mile north of Borgfeld Drive. The southern portion of the project would expand the existing US 281 main lane configuration to a six-lane expressway (two non-toll lanes, one toll lane, and an auxiliary lane for entrance/exit ramps, in each direction), with four northern direct connectors at the Loop 1604 interchange (**Figure 2**). A new three-lane frontage road would be installed at-grade on each side of the expressway in this section. The northern portion of the project would expand US 281 to an eight-lane expressway (four toll lanes and four non-toll lanes) (**Figure 3**). Along the northern portion of the project, the main lanes would be tolled and the outer lanes would function as US 281. North of Borgfeld Drive the roadway would transition down to four lanes to match the existing roadway configuration in Comal County. The proposed ROW would typically be 400 feet wide throughout the projects limits. The proposed project would require the acquisition of approximately 79 acres of new ROW.

Grade separations at cross street intersections would be provided at Sonterra Boulevard, Redland Road, Encino Rio, Evans Road, Stone Oak Parkway, Marshall Road, Wilderness Oaks, Overlook Parkway, Bulverde Road, and Borgfeld Drive to allow the main lanes to pass uninterrupted over the cross streets. No streets or driveways would access the main through lanes directly. The frontage road lanes would cross local streets at-grade via signalized intersections.

The construction phasing would begin with preparation of the ROW, followed very closely by stormwater pollution prevention device installation. Drainage structures and stream bridges would follow. Frontage roads/outer lanes would be constructed next to provide local property access and cross street connections. Traffic would remain on existing US 281 during the initial construction. Traffic would then be shifted over to the new frontage roads/outer lanes and the existing US 281 pavement would be removed. The main lanes and remaining bridge structures would be constructed. The direct connector bridges/ramps from Loop 1604 to US 281 would be built integral with the main lane construction. The water quality treatment Best Management Practices (BMPs) would be fully constructed and permanent vegetation established as part of the final construction. Construction would begin in early/mid 2016 and take about 30 months to complete.

The US 281 improvements would require fill or excavation in many areas to reach final base elevation for the new construction. Subsurface excavation for bridge supports would include footings and drilled shafts with depths up to 50 feet. Cuts for roadway excavation would range up to 23 feet in depth. Noise walls would be constructed adjacent to some residential areas. The noise wall foundations would require subsurface excavation up to 12 feet in depth. Additional excavation would also be required for project utilities and stormwater drainage with depths ranging from 10 to 15 feet.

Proposed US 281 improvement project area map.

Subsurface disturbance would also occur as a result of the removal and replacement of the existing US 281 pavement. The existing pavement structure primarily consists of a graded limestone rock base (4 inches thick) as the bottom layer and an asphalt stabilized rock base (5 inches thick) as the middle layer with an asphaltic riding surface (3 inches thick). During the removal of pavement, the asphalt surface course is removed separate from the underlying base with a pavement milling machine designed to grind and pick up the asphaltic surface, which is loaded into a truck to be recycled. The asphalt stabilized base would also be removed using the same method. The salvaged material is then hauled to a stockpile location where it can be recycled into new hot mix asphaltic pavement or transferred to other locations for use as a fill material. The graded limestone rock base is normally removed with a front-end loader or excavator and loaded immediately into a truck for delivery to a stockpile or to a location elsewhere on the project needing fill material. If the contractor is not required to remove the

Figure 2. Typical section for southern portion of US 281 improvement project.

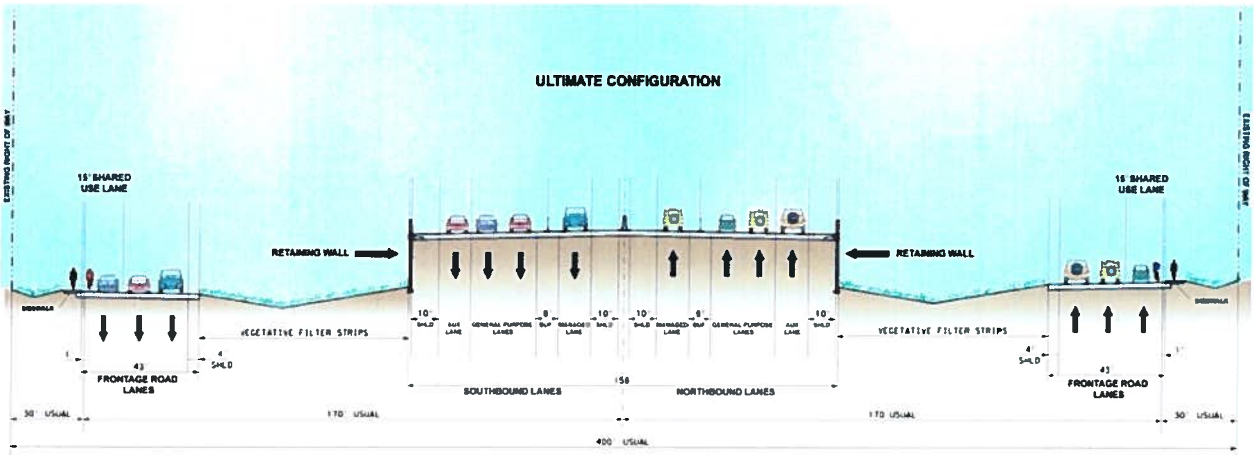
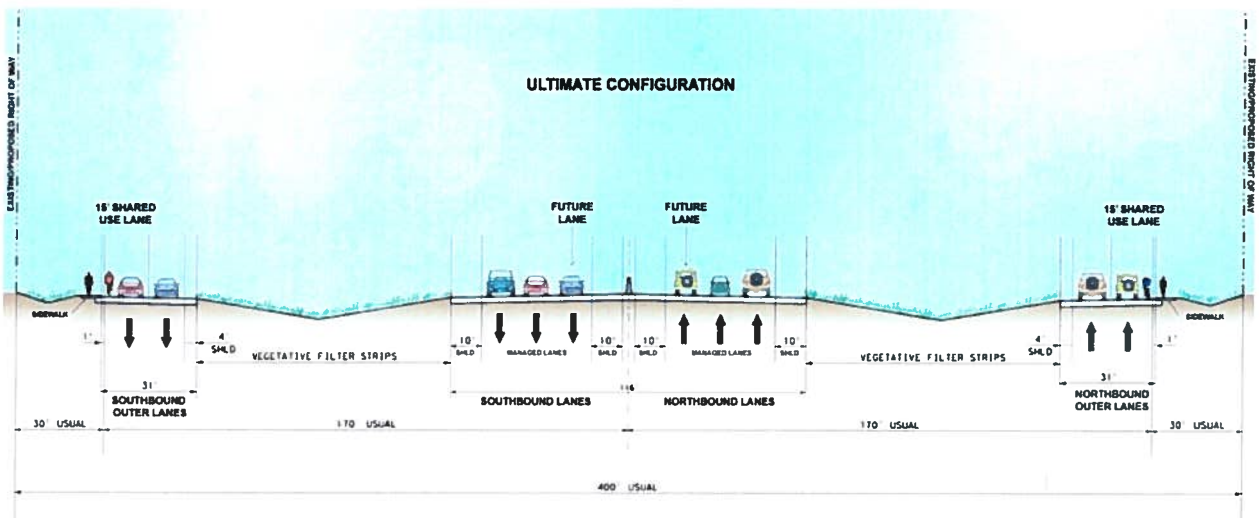


Figure 3. Typical section for northern portion of US 281 improvement project.



asphalt material using a milling machine, and the size of the material is not a requirement for recycling, then the asphalt material may be removed with a front-end loader or excavator that would scoop the material up in large chunks and then dump into a truck for transfer to an off-site location for other purposes. When salvaging the material, the contractor would not remove material deeper than the pavement structure because of the depreciation of the salvaged material if mixed with lower quality earthen material. After the pavement is removed, then the remaining earthen surface would be scarified and reshaped usually with the use of a motor-grader. The surface is then readied to receive additional fill material by disking before being compacted. Normal depth of scarifying and reshaping of material is less than 12 inches.

The construction contractor may locate project specific locations (PSLs) within the project area and/or existing ROW until such time that the area would be needed for the completion of the roadway. Specific details on PSL locations will not be available until the design is finalized and a construction contractor is chosen; however, all PSLs would be located at least 300 feet from any potential listed species habitat unless it has been surveyed in accordance with USFWS protocols to determine that the habitat is not occupied. Ultimately, the contractor is responsible for the location of PSLs and compliance with the requirements of the Act if PSLs are located outside of the ROW.

At the completion of construction, all disturbed areas would be re-vegetated according to TxDOT's standard practices for urban areas and to the extent practicable, in compliance with Executive Order 13112 on Invasive Species and the Executive Memorandum on Beneficial Landscaping. TxDOT's standard practices for roadway operations and maintenance would be implemented following the completion of post-project site restoration activities.

Conservation Measures

Impacts to *C. madla, R. infernalis* and *R. exilis* would be minimized by restricting construction impacts to the proposed action area, described below. In addition, the following voluntary conservation measures have been developed by TxDOT to avoid or minimize impacts to *C. madla, R. infernalis* and *R. exilis,* CHU 12, or other federal trust resources:

1. TxDOT would comply with the Texas Commission on Environmental Quality's (TCEQ) Edwards Aquifer Rules for development within the Contributing and Recharge Zones of the Edwards Aquifer, which require the use of temporary and permanent BMPs that treat storm water runoff from impervious cover. The regulations require the removal of 80 percent of total suspended solids (TSS) in storm water runoff from the increase in impervious cover resulting from the project. The proposed project would exceed this requirement to meet 80 percent TSS removal for the project as a whole, by meeting the 80 percent TSS removal threshold at each storm water outfall. Typically for a project of this scale the water quality treatment, or TSS removal, would occur sporadically throughout the project at concentrated sites to minimize the number of BMPs necessary to reduce the pollutant load released offsite to an acceptable level, 80 percent removal overall. This would reduce construction costs and would meet the minimum requirements of the TCEQ guidelines, yet some of the storm runoff would get released untreated. A project could over-treat some storm runoff at some locations yet let a fraction get conveyed downstream untreated. The US 281 project would remove a minimum of 80 percent of TSS at each storm water outfall, and therefore would not let any storm water runoff leave the project without first passing through a temporary (during construction) or permanent (post-construction) BMP to remove the necessary pollutant load.

2. TxDOT would minimize impacts to CHU 12 and to native vegetation, especially woodland impacts, within the proposed construction footprint. The portion of CHU 12 that touches the proposed ROW is also located within a built out subdivision, and project designers

sought to avoid impacting both CHU 12 and the residential neighborhood to the maximum extent possible.

3. The project would include five or more acres of earth disturbance; therefore, TxDOT must comply with the TCEQ's Texas Pollutant Discharge Elimination System Construction General Permit (CGP). Appropriate BMPs to minimize construction phase erosion and sedimentation impacts would be incorporated into the proposed project and related notes and diagrams would be included in required TCEQ permitting documents, such as the Storm Water Pollution Prevention Plan (SW3P), Water Pollution Abatement Plan (WPAP), and construction plans. The SW3P and WPAP would be prepared during the final design stages of the project and implemented prior to initial site disturbance, and a construction site notice would be posted on the construction site.

4. PSLs, including construction access and staging, would likely be located within the project area and existing ROW. Details on the locations of PSLs will not be available until the design is finalized and a construction contractor is chosen; however, all PSLs would be located at least 300 feet from any potential listed species habitat unless it has been surveyed in accordance with Service protocols to determine that the habitat is not occupied. TxDOT will provide an information packet to the project contractor, including information on GCW and karst species habitat that may occur within or outside of the ROW and notifying the contractor of requirements to avoid effects to listed species and their habitat.

5. The project contractor hired by TxDOT would supply a licensed Professional Geoscientist (PG) as required by the Edwards Aquifer Rules. If voids are encountered during construction, all work would stop up to 50 feet from the void site and the PG would perform an initial geologic assessment. The buffer distance may be greater if the PG or karst biologist deems appropriate. If the PG determines that the feature provides potential habitat for listed karst invertebrate species, a karst biologist holding an appropriate Section 10(a)(1)(A) permit would inspect the feature to determine its scientific or conservation value. The surface expression of the void would be covered between the time the void is opened and the time that a karst biologist is available to inspect it, in order to minimize the influence of diurnal variations in surface temperature and to retain moisture. Hazard fencing or barricades would be used to protect the area if there is a fall hazard, such as the case of an open shaft. Appropriate BMPs, including the installation of silt fencing and/or silt socks and immediate area work stoppage, would be implemented to minimize surface runoff from entering the feature.

6. TxDOT would delineate and map the subsurface drainage basins of Hairy Tooth Cave and Ragin' Cajun Cave. Cave maps would reflect locations of important features such as speleothems, fractures, and points where water enters or exits the caves. Additional information such as observed fracture and/or fault orientations, hydrologic features in bedrock (scallops, fluting, rills, cupolas, domes, etc.), secondary mineral precipitants (stalagmites, stalactites, flowstone, etc.), lithologic properties and location, and type and orientation of surface karst

features would also be included in this evaluation to determine the likely flow paths of water to the cave through the subsurface.

7. TxDOT would investigate mechanisms for updating and enhancing protection measures at Genesis Cave, which may include improved fencing around the feature, cave gating, and/or educational signs.

8. TxDOT would work with the City of San Antonio Parks and Recreation Department to survey the cave footprints, map the surface and subsurface drainage basins, and protect the caves within Stone Oak Park (CHU 21), to include Bear Cave, Cub Cave, and the Springtail cave cluster. During the construction phase of the proposed project, TxDOT would offer to develop and implement a management plan, and/or provide equipment and training for San Antonio Parks and Recreation Department staff to perform control measures for the red-imported fire ant (RIFA) (*Solenopsis invicta).*

9. TxDOT will seek to partner with TPWD, the Edwards Aquifer Authority, or other suitable organizations for educational and professional development opportunities related to karst habitat and species. TxDOT proposes to develop or enhance existing educational opportunities for local school children, such as field trips or classroom materials. TxDOT also proposes to hold up to three training sessions to educate karst professionals.

10. TxDOT has initiated a fauna assemblage study which is currently underway targeting both listed and non-listed species of *Cicurina* spiders in caves located in Bexar and adjacent counties where *Cicurina* are known to be present. The goal of this study is to better understand species distribution within this genus and to collect specimens for genetic analysis. Other karst invertebrate species found during the biota surveys are also being noted, which will enhance the scientific knowledge of those species distributions.

11. Specimens collected for the above described biota surveys, as well as those available from previous collections of *Cicurina* spiders, are being analyzed using genetic techniques. Most of these species have never been genetically analyzed and this study will provide new information about the genetic diversity and species boundaries across the study area. Juvenile *Cicurina* specimens represent a species management problem because they are the most abundant potentially listed animals detected in field studies of karst environments in Bexar County, but they are impossible to positively identify using morphological techniques. This genetic information also has great potential to help future projects where identification of juvenile specimens is needed. Listed and non-listed species can co-occur, and as juveniles their physical characteristics appear identical. The potential for using genetic techniques in this genus has been demonstrated and this work will advance the development of new tools to help ultimately solve problems with *Cicurina* identification.

12. TxDOT would re-assess and revise, where applicable, the boundaries of the karst zone and karst faunal area maps using the most up-to-date distribution information available.

13. TxDOT would revegetate all disturbed areas within the US 281 construction zone in accordance with TxDOT's standard practices for urban areas and the CGP, in compliance with Executive Order 13112 on Invasive Species and the Executive Memorandum on Beneficial Landscaping. Re-vegetation efforts would provide appropriate and sustainable cover to prevent erosion and siltation.

14. Internal TxDOT monitoring reports would be prepared monthly. The reports would include, at a minimum, information about the number and location of voids encountered and at what depth, a summary of the results of any karst invertebrate survey conducted, any observations made with a down-hole camera, a summary of the work actions completed during the reporting period and what actions are anticipated in the next reporting period. TxDOT would provide a summary report containing this information to the Service every six months during construction. Finally, TxDOT would monitor the completed project for a period of two years post-construction and submit an annual report to the Service. The annual reports would be due no later than June 15th of each year after construction is completed. The annual post-construction reports would summarize any changes observed related to listed species or their habitat within the project footprint.

Action Area

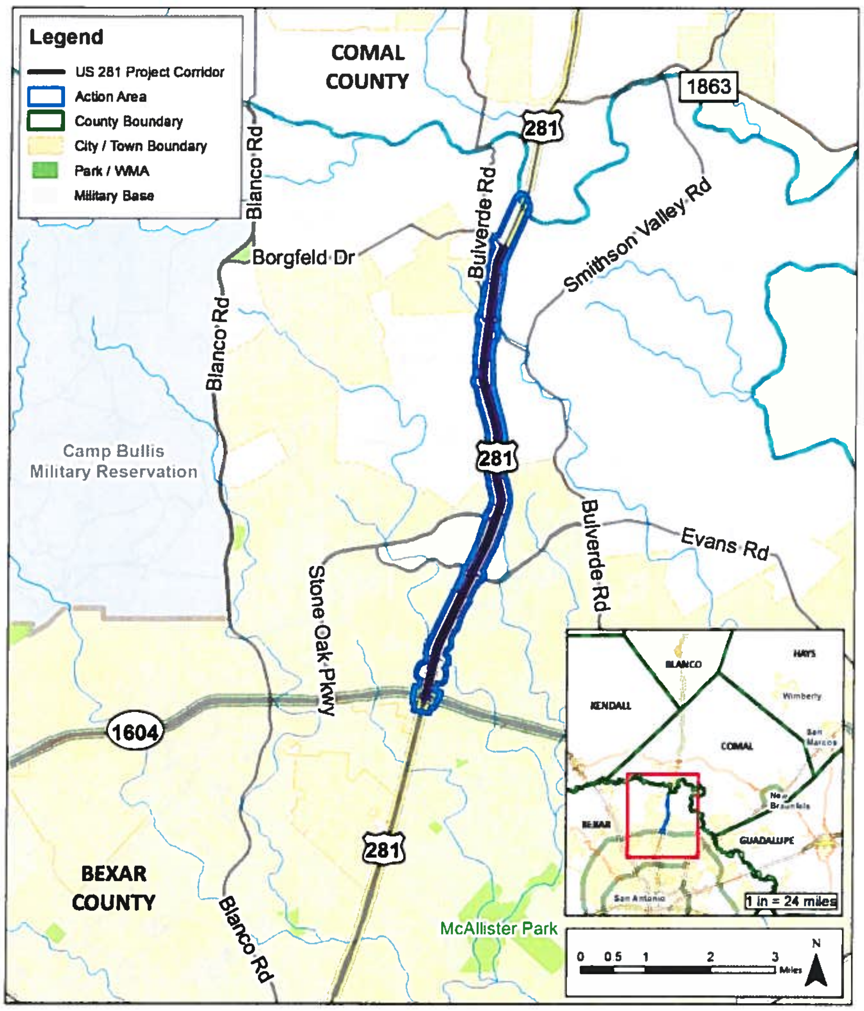
TxDOT has proposed the action area to be 1,530 acres. This includes the project footprint including the proposed new ROW (447 acres), where construction activities would occur, and a buffer of 500 feet extending outward from the project footprint (1,083 acres). The 500 foot buffer was included to capture disturbance from construction activities that have the potential to extend beyond the project footprint. Project-induced changes in surface and subsurface drainage basins, the removal of vegetation, and the addition of impervious cover may impact karst invertebrate habitat within the buffer. The action area was established to include all areas that could reasonably be expected to be directly or indirectly affected by the proposed project. Therefore, the action area proposed by TxDOT, which the Service is using for this consultation, encompasses 1,530 acres, located entirely within the Stone Oak KFR in Bexar County (**Figure 4**).

Status of the Species/Critical Habitat

<u>Species/critical habitat description</u>

Nine Bexar County karst invertebrates were federally listed as endangered species on December 26, 2000 (65 CFR 81419). The nine species listed were *R. exilis, R. infernalis, C. madla* , the Bracken Bat Cave meshweaver *C. venii*, the Government Canyon Bat Cave spider *C. vespera*, the Robber Baron Cave meshweaver *C. baronia*, the Cokendolpher Cave harvestman *Texella cokendolpheri*, the Government Canyon Cave spider *Neoleptoneta microps*, and the Helotes mold beetle *Batrisodes venyiv*). All of the listed Bexar County karst invertebrates are obligate cave species known as troglobites (animals that complete their life cycle underground and exhibit adaptation to the subsurface environment). These species are characterized by reduced or absent eyes, lack of pigmentation, elongation of sensory appendages, and low metabolic rates. Compared to surface species, troglobitic species generally have small geographic ranges and specific limitations to a particular geographic area, often related to the sub-surface geology, making them biogeographically distinct (Porter 2007, Christman et al. 2005) and particularly susceptible to extinction (Elliott and Reddell 1989, Culver et al. 2000).

Figure 4. Action area for the US 281 improvement project.



Critical habitat includes areas that are essential to the conservation of a threatened or endangered species and that may require special management considerations or protection. Critical habitat for seven of the nine listed Bexar County karst invertebrates was designated in 22 CHUs, covering about 1,063 acres, on April 8, 2003 (68 CFR 17155). Critical habitat was revised on

February 14, 2012 for all nine listed karst invertebrates (77 CFR 8450). The revised CH designation includes approximately 4,216 acres, occurring in 30 separate CHUs within Bexar County. Based on our current knowledge of the physical or biological features and habitat characteristics required to sustain the species' life-history processes, the primary constituent elements (PCEs) specific to each of the nine Bexar County invertebrates are:

1. Karst-forming rock containing subterranean spaces (caves and connected mesocaverns) with stable temperatures, high humidity (near saturation), and suitable substrates (for example, spaces between and underneath rocks for foraging and sheltering) that are free of contaminants; and,
2. Surface and subsurface sources (such as plants and their roots, fruits, and leaves, and animal (e.g., cave cricket) eggs, feces, and carcasses) that provide nutrient input into the karst ecosystem.

Habitat and Life History

There is little specific information on the life history and habitat requirements of the nine listed Bexar County karst invertebrates. This is largely because troglobites are subterranean, inconspicuous, and difficult to study (Mitchell and Reddell 1971, Chandler 1992). The term "karst" refers to a subterranean terrain that is formed by the slow dissolution of calcium carbonate from limestone bedrock by mildly acidic groundwater. This process creates numerous cave openings, cracks, fissures, fractures, sinkholes, and bedrock resembling Swiss cheese.

The northern portion of Bexar County is located on the Edwards Plateau, a broad and flat expanse of Cretaceous carbonate rock that ranges in elevation from approximately 1,100 feet to 1,900 feet above mean sea level. The principal cave-containing rock units of the Edwards Plateau are the upper Glen Rose, Edwards Limestone, Austin Chalk, and Pecan Gap Chalk formations. One-third of the cavernous rock exposed at the surface in Bexar County is of the Edwards Limestone formation (Veni 1988, Veni 1994).

Veni (1994) delineated six Karst Faunal Regions (KFRs) within Bexar County: Stone Oak, University of Texas at San Antonio, Helotes, Government Canyon, Culebra Anticline, and Alamo Heights (**Figure 5**). These KFRs are bounded by geological or geographical features that may represent obstructions to the movement (on a geologic timescale) of troglobites, which has resulted in the present-day distribution of endemic (restricted to a given region) karst invertebrates in the Bexar County area. The basis for these regions is the lack of continuity between caves, which may form complete barriers or significant restrictions to migration of troglobites over modern or geologic timescales. The KFRs are important because they are used to establish recovery criteria for individual species in the Bexar County Karst Invertebrate Recovery Plan (Service 2011a). To meet those criteria, specified numbers of preserve areas of a given quality must be protected within each KFR in which they occur.

Veni (2003) also delineated the Bexar County karst habitat into five karst zones (**Figure 6**) that reflect the likelihood of finding a karst feature that would provide habitat for the endangered invertebrates, based on geology, distribution of known caves, distribution of cave fauna, and primary factors that determine the presence, size, shape, and extent of caves with respect to cave development. As described by Veni (2003), these five karst zones are defined as:

Zone 1: Areas known to contain one or more of the nine listed Bexar County karst invertebrates.
Zone 2: Areas having a high probability of containing habitat suitable for listed karst invertebrate species.

Figure 5. Bexar County Karst Faunal Regions.

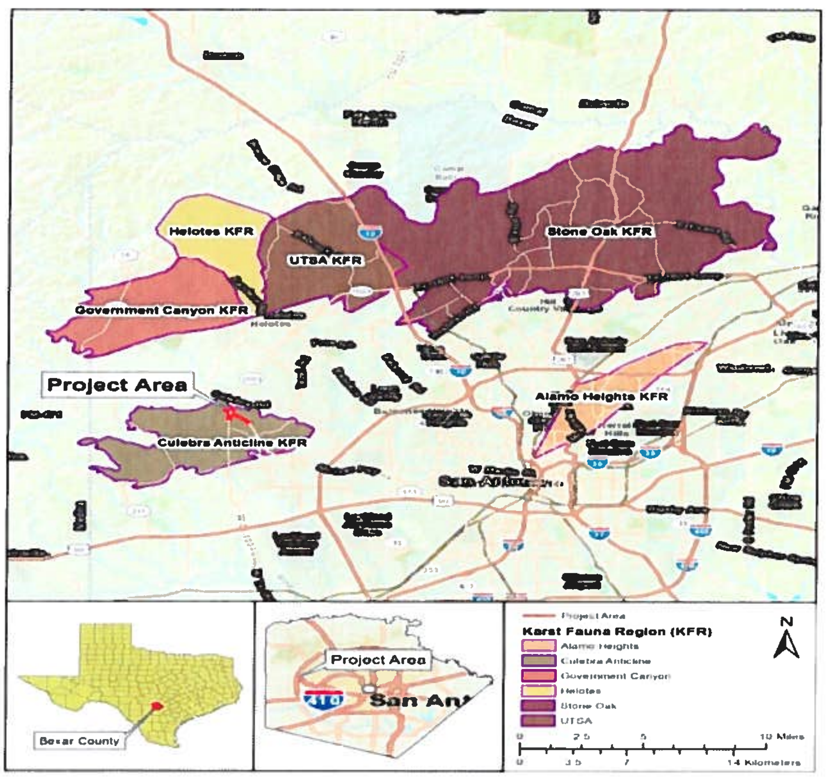
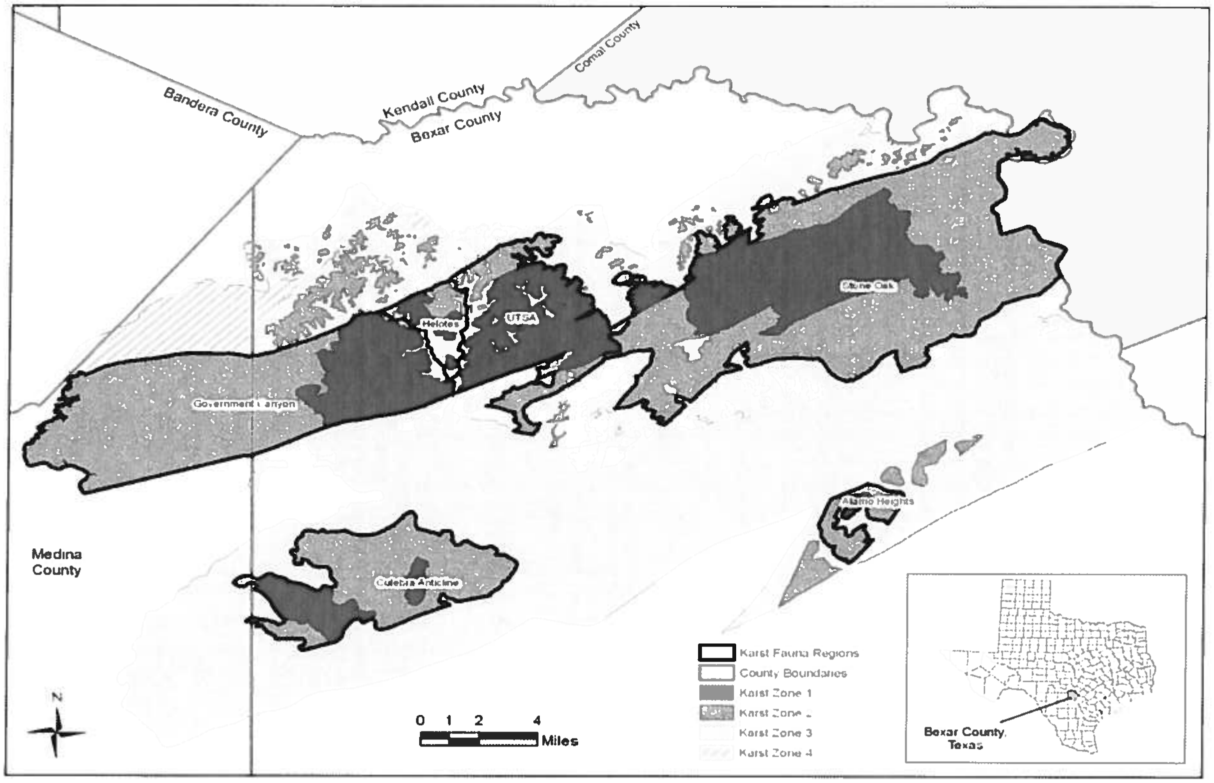


Figure 6. Karst zones in Bexar County.



Zone 3: Areas that probably do not contain karst invertebrates (may not contain suitable karst habitat).
Zone 4: Areas that require further research, but are generally equivalent to Zone 3, although they may include sections that could be classified as Zone 2 or 5.
Zone 5: Areas that do not contain listed karst invertebrates (no karst habitat present).

The nine Bexar County invertebrates require underground caves and passages with stable temperatures (Howarth 1983, Dunlap 1995) and constant, high humidity (Barr 1968, Mitchell 1971a). In addition to the larger cave passages that are accessible by humans where individuals are normally collected, these species also need mesocaverns (tiny voids that are connected to larger cave passages) (Howarth 1983), which provide additional habitat to sustain viable populations (White 2006). In order to support karst invertebrates, mesocavernous spaces should be a minimum width of 0.2 to 0.4 inch, which also corresponds to the threshold of turbulent groundwater flow that could potentially carry nutrients to karst species (Howarth 1983, Veni 1994). During temperature extremes, small mesocavernous spaces connected to caves may have more favorable humidity and temperature levels than the main cave (Howarth 1983); however, the abundance of food may be less in mesocaverns than in the larger cave passages. Therefore, the nine Bexar County invertebrates may spend the majority of their time in mesocaverns, only leaving during temporary forays into the larger cave passages to forage (Howarth 1987).

Physical factors in caves that affect the life history of the Bexar County karst species include absence of sunlight, low nutrient flow, and a stable environment with uniform temperature and humidity. These parameters favor the evolution of troglomorphic characteristics including reduction or loss of eyes, reduced pigmentation, and attenuated limbs and olfactory organs (USFWS 2011a). Additionally, nearly all cave-adapted organisms exhibit the following characteristics: delayed reproduction, larger eggs, relatively small number of total eggs produced, and increased longevity (Culver 1982). Although the average life span of any of the listed troglobitic invertebrates is currently unknown (USFWS 2011a), it is likely to be multiple years for some species, such as the *Cicurina* spiders (Bennett 1985, Cokendolpher 2004).

The nine Bexar County invertebrates need clean water that is free of pollutants to maintain stable humidity and temperatures. To maintain stable humidity, the amount of clean water varies depending on the size of the drainage basins, caves, and mesocaverns. Water enters the karst ecosystem through surface and subsurface drainage basins. Well-developed pathways, such as cave openings and fractures, rapidly transport water through the karst with little or no purification. Caves are susceptible to pollution from contaminated water entering the ground because karst has little capacity for self-purification. The potential for pollutants, such as pesticides, fertilizers, and leakage from sewer lines, may be heightened in some karst areas relative to others based on local geologic features (USFWS 1994).

The route that has the greatest potential to carry water-borne contaminants into the karst ecosystem is through the surface and sub-surface drainage basins that supply water to the ecosystem. Because cave fauna require material washed in through entrances (including human inaccessible cracks), and because they require generally high humidity, it is essential to have drainage basins with unpolluted water. The surface drainage basin consists of the area that drains from the surface into the cave entrance and other surface input sources, such as neighboring sinkholes and soil percolation. The subsurface or groundwater drainage basin includes mesocaverns, as well as subterranean streams that have a connection to the surface, but that connection is often not observable from the surface. The surface and subsurface drainage basins do not necessarily overlap, and they may be of different size and direction (Veni 2003).

Due to the absence of sunlight, and therefore primary productivity, cave organisms rely almost entirely upon surface plant and animal communities for nutrient input. Surface plant communities provide nutrients through leaf litter that enters caves or karst voids and from root masses that may grow directly into caves (Howarth 1983). In caves that do not have an opening at the surface, nutrients probably enter via dissolved organic carbon in droplets of water that pass through very small cracks, root paths, bedding planes, or other very small voids, and the nutrients then enter the cave as drips (Simon et al. 2007). Tiny arthropods, such as springtails, may also feed in the near-to-surface plant-rich soil zone and travel through these passages, ultimately becoming a food source for spiders and other predators. Primary sources of nutrients in the karst ecosystem are leaf litter, cave crickets, small mammals, and other animals that defecate or die in the cave. Because the nine Bexar County invertebrates are at the top of their food chain, habitat changes that affect their food sources (including plants and cave crickets) can affect them (Culver *et al.* 2000).

Cave crickets are an important source of nutrient input for karst ecosystems (Barr 1968, Reddell 1993). The cave crickets forage on the surface at night and roost in the cave during the day. Cave crickets provide food for karst species, which feed on their eggs, young, and feces (Mitchell 1971b, Barr 1968, Poulson *et al.* 1995). Many of the vertebrate species that occasionally use caves bring in a significant amount of energy in the form of scat, nesting material, and carcasses.

The surface plant community supports the karst ecosystem function both directly and indirectly. Dead and decaying plant material can fall or be washed into caves. Root masses reaching cave openings through soil and rock fissures may also provide direct nutrient input to shallow caves (Howarth 1983, 1988). A survey of 21 caves on the Edwards Plateau revealed that roots of six species reached caves (Jackson *et al.* 1999). Indirectly, the plant community supports cave ecosystem dynamics by providing the habitat matrix used by surface animal communities that contribute nutrient input to the karst ecosystem, including habitat needed for food, forage, and shelter by mammals, invertebrates, amphibians, and reptiles. In addition to providing nutrient input, the surface plant community buffers the karst ecosystem from changes in the temperature and moisture regimes, and sedimentation from soil erosion. It also serves to filter pollutants (to a limited degree) before they enter the karst system and protects against nonnative species invasions (Biological Advisory Team 1990, Veni 1988).

Population Dynamics

Population estimates for any of the listed karst species are not currently available due to their rarity, cryptic behavior, lack of adequate sampling techniques, difficulty and/or inaccessibility of karst habitat, including mesocavernous spaces. Generally, no more than one or two individuals are seen on a visit into a cave and often none are observed, even in karst features where they are considered relatively abundant (USFWS 1994).

Krejca and Weckerly (2007) assessed the detection probabilities of three karst invertebrates, including *Rhadine exilis*, during karst faunal surveys. The results of their study suggest that 10 to 22 visits may be required in order to confirm presence for various karst species. For example, while surveying one feature associated with the SH 151 underpass of Loop 1604, the eyeless *Cicurina* specimen was not found until the 12th survey, indicating that in this case 12 visits was enough to detect the species, but 11 was not (TxDOT 2013). Furthermore, central Texas endangered karst invertebrates have been found in caves that immediately prior to sampling had no humanly accessible entrances (Horizon Environmental Services 1991, Veni 2003, TxDOT 2013).

Status and Distribution

The primary threat to these species is habitat loss due to increased human expansion and urbanization throughout the karst terrain in Bexar County. Threats associated with increased urbanization include filling in and collapsing of caves and interstitial spaces, alteration of drainage patterns, alteration of surface plant and animal communities, introduction of invasive RIFA, contamination, and vandalism (USFWS 2011a).

As the population of the San Antonio region has increased more than 75 percent in the past 30 years and is anticipated to increase more than 60 percent over the next 30 years, growth, public infrastructure, and private development related to growth is reasonably certain to occur within the Culebra Anticline (Loomis et al. 2014). Impacts to listed karst species from increased development may result from additional impervious cover, removal of surface vegetation, increased pollution, modification and/or destruction of karst features, and alterations to the surface and subsurface hydrological regimes. Development would remove natural vegetative cover; therefore, reduce cave cricket foraging areas and the potential carrying capacity for karst invertebrate habitat. Removal of woody surface vegetation may result in a reduction of vegetative root matter penetrating into subterranean voids, a potential point source for the introduction of nutrients into karstic ecosystems. Fragmentation of natural areas may result in a decreased occurrence of trogloxene species (e.g. cave crickets) that may dwell in karst features and directly import nutrients from the surface to the subsurface. In addition, development would increase the amount of impervious cover in the area, which would result in increased surface pollution runoff and in alterations to surface and subsurface hydrological regimes as water is redirected to man-made drainage systems. These changes may alter the quality and quantity of water entering karst voids.

Construction and development activities that do not destroy a cave entrance can still result in collapse of the cave ceiling or other adverse effects on the karst environment. On ranch land or in rural areas, it is not uncommon to use caves as trash dumps (Culver 1986, Reddell 1993) or to cover the entrances to prevent livestock from falling in (Elliott 2000). These activities can be detrimental to the karst ecosystem by causing direct destruction of habitat or altering the natural passage of organisms, water, detritus, and other organic matter into a cave. Quarrying of limestone and road base material is a widespread activity that can remove vegetation and destroy karst habitat. A number of occupied caves in Bexar County have been severely impacted in the past, and an examination of recent aerial photography reveals recent impacts to karst habitat near several other occupied caves.

Cave organisms are adapted to live in a narrow range of temperature and humidity. To sustain these conditions, both natural surface and subsurface flow of water and nutrients must be maintained. Decreases in water flow or infiltration may result in reduced humidity, slowing the rate of decomposition, while increases in water entering voids may flood habitats, cause drowning of void inhabitants and may wash away nutrients (USFWS 2011a). Alterations to surface topography, including decreasing or increasing soil depth or adding nonnative fill, can change the nutrient flow into the cave, and affect the cave community (Howarth 1983). Changes in the amount of impermeable cover, collection of water in devices like storm sewers, increased erosion and sedimentation, and irrigation and sprinkler systems can affect water flow to caves and the surrounding karst. Changes in the quantity of water, its organic content, the timing and extent of flood pulses, or droughts may negatively impact the listed species.

Karst ecosystems are heavily reliant on surface plant and animal communities to maintain nutrient input, reduce sedimentation, and resist exotic and invasive species. As the surface around a cave entrance or over the associated karst ecosystem is developed, native plant communities are often replaced with impermeable cover or exotic plants from nurseries. The abundance and diversity of native animals may decline due to decreased food and habitat, combined with increased competition and predation from urban, exotic, and pet species. As surface plant and animal communities are destroyed, food and habitat once available to trogloxenes decreases. Destruction of plant communities can lead to increased erosion that causes sedimentation within caves. Where native woodland and grassland communities are present, a perimeter area is needed to shield the core vegetation habitat from impacts associated with edge effects or disturbance from adjacent urban development (Lovejoy *et al.* 1986, Yahner 1988). Effects from such impacts can include increases in invasive species and pollutants, and changes in microclimates, which can adversely affect the listed species by impacting nutrient cycling processes important in cave/karst dynamics and the overall health of karst invertebrates.

Much of the habitat occupied by the Bexar County invertebrates is particularly sensitive to groundwater contamination, because little or no filtration occurs, and water penetrates rapidly through bedrock conduits (White 1988) and mesocaverns (Cowan et al 2007). The ranges of these species are becoming increasingly urbanized, and, thereby, they are becoming more susceptible to contaminants including sewage, oil, fertilizers, pesticides, herbicides, seepage from landfills, pipeline leaks, or leaks in storage structures and retaining ponds. Activities on the surface, such as disposing of toxic chemicals or motor oil, can contaminate caves (White 1988). Materials like cleaning agents, industrial chemicals, and heavy metals can also easily infiltrate subterranean ecosystems by the pollutants leaching into the karst, for example, from leaking underground storage tanks, or by being washed into the surface or subsurface drainage area. Contamination of karst habitat can also occur from the deposition of air pollutants in the surface or subsurface drainage area and improper disposal of litter, motor oil, batteries, or other household products in or near caves (White 1988).

Continued urbanization would increase the likelihood that karst ecosystems are polluted by contamination from chemical leaks and spills, which often have occurred in Bexar County. The TCEQ (2010) summarized information on groundwater contamination reported by a number of agencies, and listed 109 groundwater contamination cases that occurred in Bexar County between 1980 and 2000; the majority of them were spills or leaks of petroleum products. Groundwater contamination poses a threat to entire karst ecosystems and is particularly difficult to manage because pollutants can originate far from the sensitive karst site and flow rapidly through the subsurface (White 1988).

Red-imported fire ants are a pervasive, nonnative ant species originally introduced to the United States from South America over 50 years ago and are an aggressive predator and competitor that has spread across the southern United States. Karst invertebrates in central Texas are especially susceptible to RIFA predation because most caves are relatively short and shallow. This threat is exacerbated by activities that accompany urbanization and that result in soil disturbance and disruption to native ant communities. RIFA have been found within and near many caves in central Texas and have been observed feeding on dead troglobites, cave crickets, and other species within caves (Elliott 1992, 1994, Reddell 1993, Taylor *et al.* 2003). They often replace native species, and evidence shows that overall arthropod diversity, as well as species richness and abundance, decreases in infested areas. Hot and dry weather may also encourage RIFA to move into caves during summer months, and cold weather may cause them to seek refuge or prey in the caves during the winter. Besides direct predation, RIFA threaten listed invertebrates by reducing the nutrient input that fuels the karst ecosystem. Taylor *et al.* (2003) found that cave crickets often arrived before RIFA at baits placed above ground at night, but the arrival of RIFA corresponded to the departure of cave crickets, indicating competition for at least some food resources. Lavoie *et al.* (2007) also reported that cave crickets and RIFA ate the same baits. Of 36 caves visited during status surveys for the nine Bexar County karst invertebrates, RIFA were found in 26 of them (Reddell 1993).

Models suggest climate change may cause the southwestern United States to experience the greatest temperature increase of any area in the lower 48 States (IPCC 2007). There is also high confidence that many semi-arid areas like the western United States would suffer a decrease in water resources due to climate change (IPCC 2007), as a result of less annual mean precipitation (Christensen *et al.* 2007). These predictions underscore the importance of special management to maintain karst moisture and temperature levels to ensure survival of the nine karst invertebrates.

In summary, threats to the nine Bexar County invertebrates include clearing of vegetation for commercial or residential development, road building, quarrying, or other purposes. Infestation by nonnative vegetation causes adverse changes in the plant and animal community and possibly in moisture availability. An increase in RIFA can occur with development and cause competition with and predation on other invertebrates in the karst ecosystem. In addition, filling cave features for construction, ranching, or other purposes can adversely affect the listed invertebrate species by reducing nutrient input, reducing small mammal access, and changing moisture regimes. Excavation for construction or operation of quarries can directly destroy karst features occupied by any of the nine Bexar County invertebrates, including the mesocaverns they use.

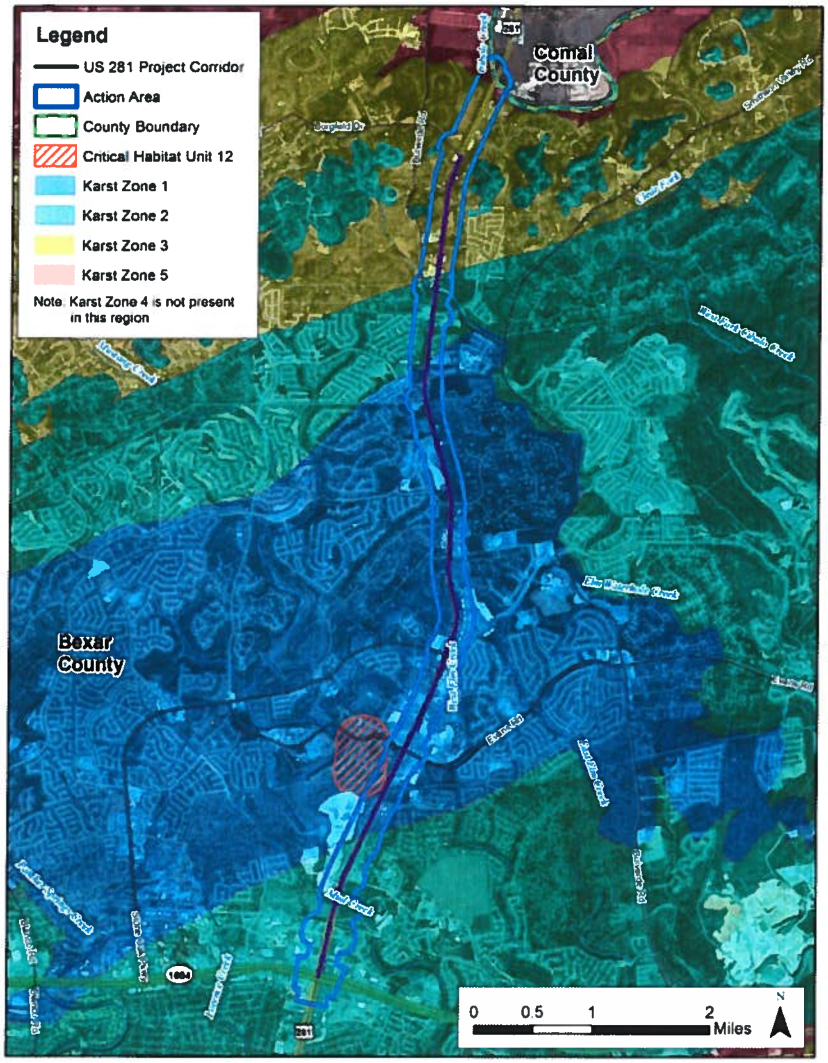
Status of the species/critical habitat

The action area for the US 281 project, between Loop 1604 and Borgfeld Drive, falls entirely within the Stone Oak KFR. A majority of the action area is classified as Karst Zones 1 (749 acres), areas that are known to contain listed karst species, and Karst Zone 2 (453 acres), areas with a high probability of containing listed karst species (**Figure 7**). The northern portion of the project is classified as Karst Zone 3 (291 acres) and 5 (19 acres), which do not, or are not known to, contain suitable karst habitat for listed karst invertebrates. There are also 18 acres of the action area that is outside of mapped Karst Zones. Three federally listed endangered karst invertebrate species are known to occur in the Stone Oak KFR: *C. madla, R. infernalis,* and *R. exilis*. Stone Oak KFR is about 58,539 acres in size, and most of the KFR is classified as Karst Zones 1 or 2.

Rhadine exilis is currently confirmed in 53 caves in the Government Canyon, Helotes, UTSA, Culebra Anticline, and Stone Oak KFRs and may occur in two additional caves in the UTSA KFR in Bexar County (USFWS 2011b) (**Figure 8**). The currently understood range of this species overlaps with the US 281 project area, including CHU 12, which was created for *R. exilis*; however, CHU 12 is the only known location for *R. exilis* within the US 281 action area and presence/absence surveys performed in 2010 did not result in any observations or collections of this species.

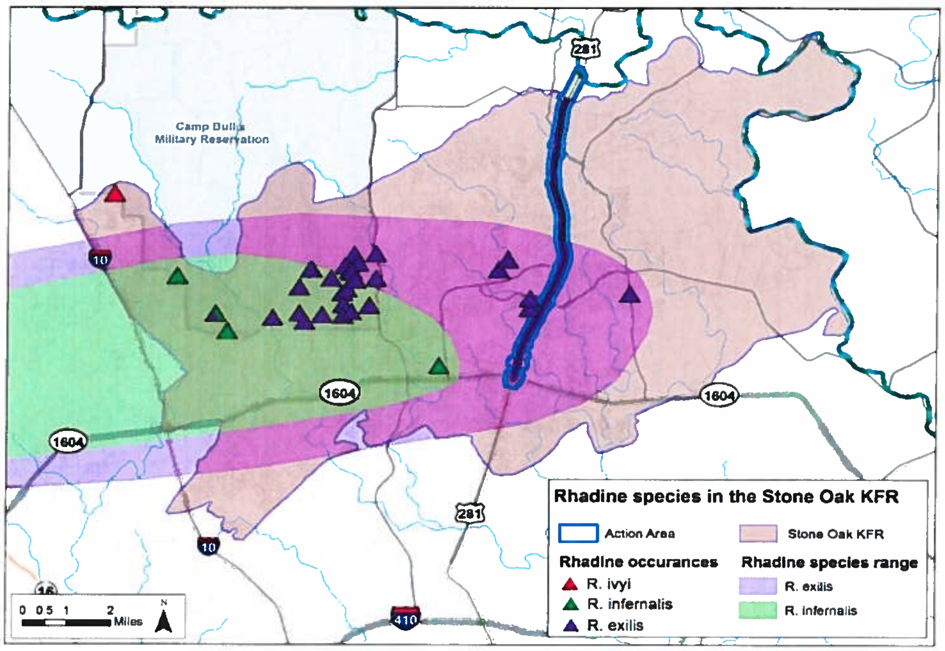
R. infernalis is a small, robust, reddish-brown beetle with minute eye rudiments and a narrow neck, with a total body length which averages about 7.2 millimeters. *Rhadine infernalis* is known from 39 caves in the Culebra Anticline, Helotes, UTSA, and Stone Oak KFRs (USFWS

Figure 7. Karst zones within and surrounding the US 281 improvement project action area.



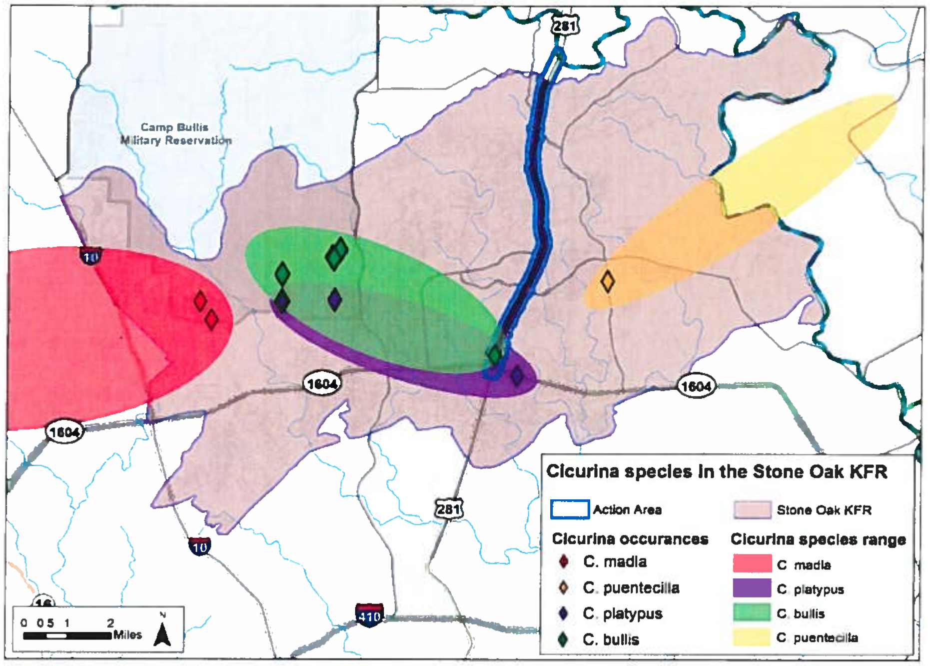
2011b) (**Figure 8**). The closest confirmed location of this species is in Genesis Cave, approximately 1.7 miles west of the US 281 project corridor, west of Stone Oak Parkway and north of Loop 1604, and there are no known localities within the US 281 action area. Presence/absence surveys performed in 2010 within potential habitat did not result in any observations or collections of this species.

Figure 8. *Rhadine* beetle locations and known ranges in the Stone Oak KFR.



C. madla is a small eyeless spider with reduced pigment. *C. madla* has been confirmed in 22 Bexar County caves in the government Canyon, Helotes, and Stone Oak KFRs, and may occur in additional caves in the Helotes and Stone Oak KFRs (USFWS 2011b) (**Figure 9**). The eastern limit of the current range for this species is located seven miles west of the US 281 action area in Camp Bullis within the Stone Oak KFR, and there are no known localities within the US 281 action area or outside of Camp Bullis within the Stone Oak KFR. Presence/absence surveys performed in 2010 within potential habitat in the US 281 project area did not result in any observations or collections of this species; however, knowledge of the distribution of eyeless *Cicurina* species in Bexar County is constantly changing, as specimens are collected from additional sites. This can result in range extensions, some of which that may leap over or around the ranges of other species in the genus. The taxonomy of *Cicurina* populations is expected to change with further genetic analysis. When species of the genus were first described, they were done so solely on a morphological basis, which only considers adult specimens. TxDOT is currently conducting genetic research on *Cicurina* species in Bexar and surrounding counties with the goal of developing molecular techniques to discriminate between species reliably.

Figure 9. *Cicurina* species locations and known ranges in the Stone Oak KFR.



In December 2002, 475 caves were known in Bexar County and at least 97 of those had been sealed or destroyed, including some that had not been biologically studied (Veni 2003). Based on observations of fauna, several of the blocked or destroyed caves were likely occupied by listed species (Veni 2003). As of December 2013, 605 caves were known to occur in Bexar County (George Veni pers. comm. 2013). At least 93 caves have been confirmed to contain listed karst invertebrates (USFWS 2011a); however, because of the lack of complete sampling, it should be noted that this is not likely to represent the complete range for these species. Also, many of the caves are lacking the recommended protection of a minimum of 40 acres of contiguous, unfragmented, undisturbed land to maintain both the native plant and animal communities around the feature that would help protect the integrity of the cave community (USFWS 2011a).

There are seven CHUs within the Stone Oak KFR (**Figure 10**), but only one crosses into the project action area. CHU 12 is a 166 acre unit located within a residential subdivision on the west side of US 281 (**Figure 11**). CHU 12 consists of two caves, Hairy Tooth Cave and Ragin' Cajun Cave, both containing *R. exilis*. The CHU is located mostly within the residential subdivision, with a small portion (0.023 acre) extending into the US 281 ROW. CHU 12 was delineated by drawing 100-acre circles around each of the caves in the unit and joining the edges of the overlapping circles, then removing an area to the south, where an existing limestone quarry is in operation.

Areas of undisturbed native vegetation and associated wildlife, both primary constituent elements of CH, are sparse within the CHU. Typical vegetation within the subdivision consists of non-native turf grasses and ornamental shrubs and flowering plants. Vegetation within the ROW consists of sparse patches of woody vegetation and grasses. Hairy Tooth Cave is surrounded by roads on three sides and a residence on the fourth. Ragin' Cajun Cave is located in a 0.6 acre fenced lot bounded by roads on two sides and residences on the other sides. Significant disturbance has occurred within the surface and subsurface drainage basins of the two caves in this CHU due to residential development, conversion of native vegetation to turf grasses and ornamental shrubs, the installation of roads and underground utilities, and the adjacent limestone quarry operation.

Figure 10. Critical Habitat Units in the Stone Oak KFR and their proximity to the proposed action.

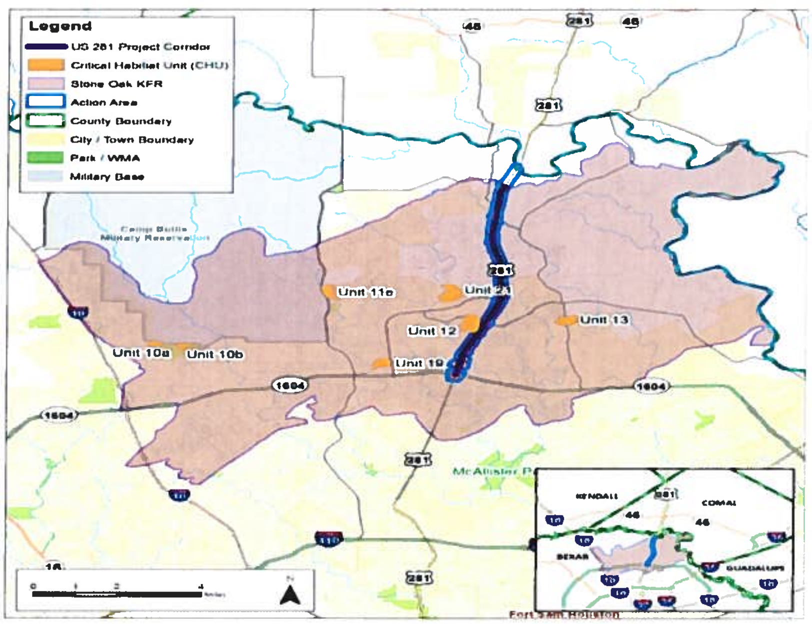
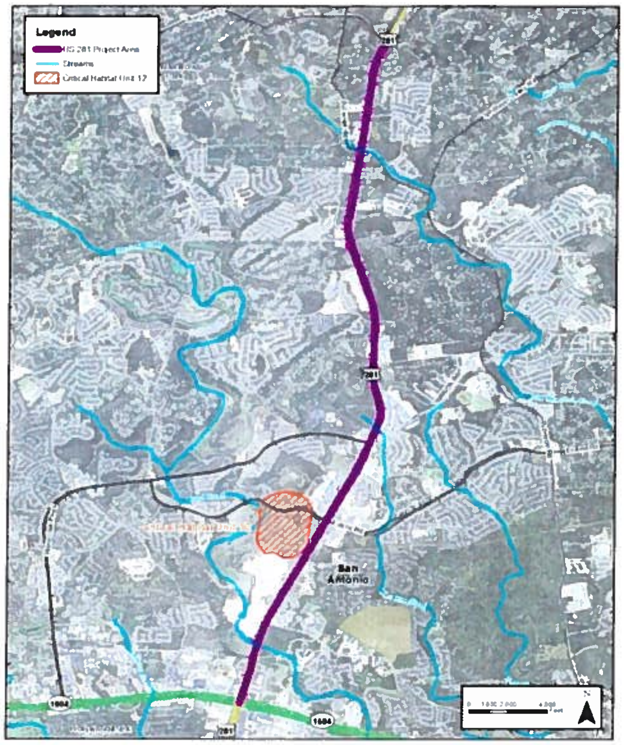


Figure 11. CHU 12 location in reference to the overall US 281 project.



Environmental Baseline

Under section 7(a)(2) of the Act, when considering the effects of the proposed action on federally listed species, the Service is required to take into consideration the environmental baseline. The environmental baseline includes past and present impacts of all Federal activities in the action area (50 CFR 402.02) that have already undergone section 7 consultation, and any other State or private actions which are contemporaneous with the consultation in progress.

<u>Status of the species within the action area</u>

In 2009 and 2010, TxDOT's biological consultants performed karst feature surveys throughout the entire project ROW and in all properties granting access within 500 feet of the ROW to search for karst features (TxDOT 2010). A total of 116 features were recorded during field surveys. Sixty features were determined to be karstic in nature and warranted further investigation, with 45 caves excavated and evaluated for potential karst species habitat. Landowners did not grant permission to access the remaining 15 features; therefore, these features could not be assessed. The karst evaluations identified 13 caves that were determined to contain potential habitat for karst invertebrate species. Presence/absence surveys, using the Service's 2006 karst survey protocol, indicated that 10 features contained non-listed troglobites, including two occupied by rare, but non-listed, invertebrates. No federally listed karst species were found in any feature surveyed within the projects action area.

R. exilis is the only listed species known to occur within the projects action area. It is known to occur in both caves making up CHU 12. While karst habitat occurs within the project action area and would be impacted by the proposed project, karst surveys conducted in 2009 and 2010 did not identify any other karst features in the action area containing listed karst invertebrates. The closest known location for *R. infernalis* is Genesis Cave, which is about 1.7 miles west of the proposed project. The only known location for *C. madla* in the Stone Oak KFR is in Camp Bullis, which is located about seven miles west of the project area.

The entirety of CHU 12 occurs within the project action area and about 0.023 acre of the CHU occurs within the existing ROW and proposed construction area. A more detailed description of CHU 12 is located above in the *Status of the species/critical habitat section.*

Factors affecting the species within the action area

The action area for this project includes the US 281 ROW and a 500 foot buffer beyond the outer edge of the ROW. The Service believes this action area represents the limits of where direct and indirect adverse effects to listed karst species are likely to occur due to the project; however, if a contaminant spill were to occur the effects could extend beyond the action area. The action area encompasses about 1,530 acres. **Table 2** breaks the action area down into areas that would be directly impacted by the project (447 acres), which includes all areas within the existing and proposed ROWs, and areas extending 500 feet beyond the ROW, where indirect effects might occur (1,083 acres). Within the action area, a total of 876 acres have been impacted by existing development or would be impacted by the proposed project. It is estimated that an additional 522 acres within the action area would be developed within the next 20 years, leaving only 132 acres undeveloped, which are undevelopable or constrained from development in some way.

Table 2. Existing conditions and impacts in the project action area.

Area	Acres	% of Action Area	% of KFR
Total action area	1,530	100	2
Existing US 281 footprint and ROW in action area	447	29	0.7
500 foot buffer beyond ROW with only indirect effects	1,083	71	1.3
Development within the action area (including project)	876	57	-
Potential future development within the action area	522	34	-
Undevelopable areas within the action area	132	9	-
Stone Oak KFR	58,839	-	100

A large portion of the action area, about 797 acres, has been previously disturbed by the existing configuration of US 281 and its ROW, other surface streets, and residential or commercial development. The proposed project would increase the amount of disturbed ROW by 78.8 acres. An additional 172 acres of vegetation would be cleared, of which 138 acres is located in karst zones 1 and 2. The project would result in the removal of almost one million cubic yards of subsurface material, half of that volume would come from Karst Zone 1 (513,357 yd^3), with an additional 20 percent from Karst Zone 2 (194,766 yd^3). A description of the subsurface excavation needed for the project between stations which correspond to the Preliminary Schematic Drawings can be found in TxDOT's BA.

There have been several prior section 7 consultations within the action area, including consultations for previous modifications to US 281 in this area. A US 281 superstreet operational improvement project was evaluated for listed species effects, with a "No Effect" determination made. The project construction was completed in 2010. An informal consultation was done for *R. infernalis* and *C. madla* on the Loop 1604/US 281 interchange in 2010. The project included four direct connectors, which were located on the southern side of Loop 1604.

Effects of the Action

<u>Factors to be considered</u>

Proximity of the action

The closest known location for *R. exilis* is within the action area in the two caves (Hairy Tooth and Ragin' Cajun) which make up CHU 12. These features would not be directly affected by the vegetation removal, excavation or project construction associated with developing the US 281 project, but the possibility that they could be indirectly affected is greater than discountable or insignificant. In addition, mesocaverns that connect may occupied karst features and underlie the project area could be impacted. There are no known *R. infernalis* or *C. madla* locations within the action area, with the closest being Genesis Cave, located 1.7 miles away, and Camp Bullis, located seven miles away, respectively. There is also a high likelihood that additional, currently unknown, karst features would be discovered during construction. These karst features would be within the known range of these species and it cannot be discounted that they could be present.

Distribution

The proposed construction of the US 281 improvement project would occur entirely within the Stone Oak KFR; however, the action area consists of only a small portion, about two percent, of the Stone Oak KFR. A majority of the action area has been delineated as Karst Zone 1 (749 acres) and Karst Zone 2 (453 acres), which have a high potential to contain habitat for listed karst invertebrate species (Veni 2003). The amount of cleared ROW would be increased by about 78.8 acres for construction of the project. Approximately 172 acres of vegetation would be removed and 98 acres of impervious cover would be added for the proposed project. The construction footprint and cleared ROW and vegetation would also affect an unknown amount of subsurface karst habitat and mesocaverns within the action area. The direct effects would be localized to the US 281 ROW, with indirect effects potentially extending out for an additional 500 feet. A majority of the construction area is already developed, containing the existing road pavement, residential/commercial development, or vegetated ROW.

Timing

The projects disturbance of surface and subsurface habitat would occur only once at any given point, although exposure may be prolonged during construction. The project would take several years to complete; therefore, it would span all climatological seasons. Karst invertebrates require stable temperature/moisture regimes associated with subterranean karst habitat. Karst voids that are exposed during construction would be closed as quickly as possible to maintain environmental conditions within the voids. Project effects would occur throughout the life of the project and could affect the karst species at any stage of their life cycle.

Nature of the effect

The effects associated with highway construction activities would directly alter the karst habitat within the action area, if karst voids are encountered during construction. However, the project would not affect the overall population size, variability, or distribution outside of the action area. The project has been designed to minimize impacts to the karst invertebrates and effects would only occur within the 1,530 acre project action area. If any karst features are uncovered during construction, TxDOT would investigate the feature to determine if karst invertebrate habitat exists in the feature. If possible, impacts to the newly discovered features would be avoided or minimized and the feature would be permanently closed.

Duration

Work is proposed to begin on the project in the spring of 2016 and would take between four and five years to complete. The direct effects to the karst invertebrates would occur during drilling of geotechnical boreholes and shafts for bridge foundations, land clearing activities in the expanded ROW, excavation to reach final road grade or to remove the existing roadway, construction of the roadways, or installation of utilities, drainage culverts, and water quality BMPs. Indirect effects, such as alterations of the species ability to carry out their normal lifecycle, including emigration/immigration across the project work zone, would persist throughout the action area until project completion and vegetation has been reestablished in the work areas within the ROW. Direct effects would be permanent once they occur. Indirect effects would be permanent or temporary and could occur repeatedly over an extended period of time.

Disturbance frequency, intensity, severity

The proposed project would consist of several separate, but related, events. First, the four northern connectors between 1604 and US 281 would be constructed. Next, the new frontages roads for the section of US 281 between 1604 and Stone Oak would be constructed, then the existing main lanes would be removed and the new main lane configuration constructed. Finally, the new main lanes for the northern section, between Stone Oak and Borgfeld would be constructed, followed by removal of the existing roadway and construction of the new tolled lanes.

Project construction would begin immediately after final construction schematics are completed. Any vegetation within the new ROW would be removed completely at the onset of construction and the disturbance would continue throughout construction on the project. Any karst invertebrate habitat located in the ROW prior to the start of construction would be impacted, however, the direct effects to the karst invertebrates would be limited to activities that require excavation of subsurface habitat. The existing roadway would be removed during construction, but this would occur in areas that were previously disturbed and would likely not result in direct effects to karst invertebrate habitat.

Analysis for effects of the action

Beneficial effects

All of the Conservation Measures proposed by TxDOT for this project would benefit these species to some degree. Delineation of the surface and/or subsurface drainage basins and the implementation of additional protective measures and public education of several other occupied karst features in the Stone Oak KFR would improve existing protections for those features. Both the biota study and the *Cicurina* genetic analysis are associated with recovery actions for downlisting/delisting these species in the Bexar County Karst Invertebrate Recovery Plan (Service 2011a). The proposed public outreach and educational actions are also identified recovery actions.

The ongoing biota study that TxDOT is undertaking as a Conservation Measure for this project would directly benefit *C. madla, R. exilis* and *R. infernalis,* and possibly some of the other endangered karst invertebrate species in Bexar County, by supplying information on the current status of listed karst invertebrate species in caves with little or no existing monitoring. Additional benefits include supplying inventories of other cave invertebrates, such as cave crickets, that serve as a proxy for the health of cave invertebrate habitat as well as general observations of the health of the cave and its surroundings. The results of this study would further the knowledge of terrestrial karst fauna distribution in Bexar County and provide an updated status of the general health of undermanaged caves with known endangered species. In addition, this study promotes specific recovery actions itemized in the Bexar County Karst

Invertebrates Recovery Plan (Service 2011a). These include identifying, and potentially protecting, KFAs needed to meet recovery criteria, monitoring populations, gathering distribution information, and conducting genetics research to determine genetic diversity across the range.

C. madla and other *Cicurina* species in Bexar County would benefit from the genetic analysis being sponsored by TxDOT. If the genetic analysis is successful at differentiating *Cicurina* species, it would aid in the future identification of juvenile and male *Cicurina* individuals, which currently cannot be identified to the species level (Cokendolpher 2004), encountered during karst species surveys. The information gathered would also help further the understanding of *Cicurina* species boundaries, genetic diversity, and descriptions of genetic characteristics of specimens, enhancing the effectiveness and efficiency of future studies.

Direct Effects

Direct effects occurring from the proposed project would be related to ground disturbing activities, such as geotechnical boreholes, bridge foundation shafts, roadway excavation, and installation of water quality BMPs. A detailed description of the impacts associated with the different types of ground disturbing construction activities is located below. Any of these ground disturbing activities may entirely or partially remove a subsurface void in bedrock that contains habitat for karst invertebrate species. Any activity that alters the soil surface and underlying geology could result in harm, via direct death or injury, to individual karst invertebrates, if occupied karst habitat is located at the disturbance site. Harm could also result from significant modification or degradation of the karst habitat, such as alteration of surface and subsurface drainage patterns, changes to temperature and humidity regime, changes to mesocaverns connectivity, or changes to water flow and nutrient input that results in death or injury. The project may also result in harassment of listed karst invertebrates if project components disrupt essential behavioral patterns, including breeding, feeding, or sheltering. The total area of direct disturbance within the action area is equal to all areas within the project ROW, 447 acres.

Direct effects to karst invertebrate habitat may also occur due to surface disturbances such as vegetation removal, which may result in fragmentation of trogloxene (e.g. cave crickets) foraging areas, alterations in nutrient input and outflow, reduction in the carrying capacity of karst habitat, and the introduction of invasive species. Up to 172 acres of wooded and unmaintained vegetation would be removed by the proposed project. The majority of this vegetation is located within Karst Zone 1 (103 acres), followed by 35 acres in Karst Zone 2, 33 acres in Karst Zone 3 and one acre in Karst Zone 5. In cases where voids are mostly intact, exposure of subsurface habitat can cause climate alteration such as temperature swings, desiccation, or flooding. Other direct effects to karst invertebrate habitat occur within and adjacent to the project area due to the placement of impervious cover (bridge decks, roadway surfaces, etc.) and alterations in surface and subsurface drainage that may result in changes to previously stable temperature and moisture regimes in karst habitat. Approximately 98 acres of impervious cover would be added by the proposed project.

Geotechnical Borehole Impacts

Geotechnical boreholes are typically small diameter (2 to 12 inch) holes that do not result in total destruction of karst voids. The depth of geotechnical boreholes can vary depending on the needs of the project, but would not exceed 80 feet for this project. When a void is encountered in a borehole, the drill bit penetrates the ceiling or wall of the void, causing some debris (drilling tailings) and water (if used as a bit lubricant) to enter the void. As voids encountered in geotechnical boreholes are located at some depth within a borehole, the potential for climate alteration is minimal. Drilling of the borehole may induce airflow to subsurface voids; however, a narrow opening, typical of most boreholes would not result in as much desiccation as would occur if the void were directly exposed to the surface. Voids intersected by boreholes may be preserved by plugging the borehole above the void, typically using bentonite clay, or backfilled with the material removed to prevent the introduction of potentially contaminated surface runoff into groundwater.

Pier Drilling Impacts

Drilling for the installation of support piers for bridges and ramps involves drilling larger shafts ranging from 3 to 15 feet in diameter with depths typically between 12 and 50 feet. Drilled shafts for piers have the potential to entirely destroy a karst void, or remove a significant portion of it, depending on the diameter of the shaft. A void encountered in a drilled shaft may be exposed to significant climate alteration, though perhaps not as much as in the cases of milling and excavation.

Surface Milling and Grading Impacts

Surface milling is used to evenly lower the grade of bedrock by several inches at a time over wide areas to provide an even surface for subgrade layers in roadway projects. As a milling machine passes over an area it removes surface bedrock and leaves behind a pile of cuttings including small rocks and dust. Cuttings are then piled up by other machines and loaded into dump trucks for removal or reuse. Graders are also used to scrape materials from the ground surface after milling to achieve a particular slope. Impacts to voids encountered by milling and grading activities would vary depending on the vertical and horizontal extent of the void, and whether the void is situated in the floor of the milled or graded area or in the wall. If a large portion of a void is exposed, climate alteration would be exacerbated. If only a narrow opening to void is created, climate alteration may be minimal. In either case, flooding can still occur on the floor of the downcut area, especially if it has the aspect of a large trench, channeling floodwaters.

Excavation Impacts

Excavation equipment such as trackhoes and trenchers are typically used in smaller areas than milling and grading equipment; however, the depths impacted may be greater. Most excavation and trench work on roadway projects is for the placement of stormwater conveyances and water quality facilities or for the removal of the existing road bed. Trackhoe operators typically have a good view of the excavation and can visualize voids as they are encountered. Trenchers come in two basic types, either a large wheel or a chainsaw-like arm, both with large rock-cutting teeth on them. Since the trench is narrow, visibility for detecting voids encounters in minimal. Voids exposed in excavations and trenches would be subject to similar climate alterations as those in pier drill holes, and would be particularly subject to flooding from rainfall runoff.

Engineers have attempted to quantify the amount of material that would be excavated in order to accomplish the proposed design based on preliminary schematics. Areas have been identified within Karst Zones 1, 2, and 3 where the removal of subsurface limestone that may intersect or remove voids containing potential habitat for karst invertebrates is necessary during construction activities. **Table 3** lists the project related ground disturbing construction activities, along with the maximum depth and volume affected, that could result in direct effects to the listed karst invertebrates within the action area. An estimated total 997,844 cubic yards of subsurface limestone would be directly impacted by construction activities for the proposed project. This volume is broken down by activity and by karst zone in **Table 3**. Descriptions of roadway excavations by station number are also described in the BA. The terrain in the US 281 corridor is very irregular transversely and longitudinally; therefore, anticipated maximum downcutting for roadway excavation ranges from 1 to 23 feet. The maximum depth of drilled shafts for geotechnical boreholes and bridge foundations are 80 and 50 feet respectively.

Table 3. Ground disturbing activities associated with proposed US 281 construction activity interchange (based on preliminary schematics).

Excavation Source	Maximum Depth (ft)	Total Excavation Volume (yd^3)
Geotechnical Boreholes	80	38
Drilled Shaft Bridge Foundations	50	11,062
Roadway Excavation	23	903,459
Storm Drainage	15	20,352
Water Quality BMPs	10	62,313
Noise Wall Foundations	12	620
Total		**997,844**

Direct effect to CHU 12 would be limited to the 11 feet of the CHU that extends into the ROW, totaling only 0.023 acre. The direct alteration within the CHU would be from the removal of an extremely small amount of vegetation from the CHU. In addition, subsurface impacts could occur from the removal of about 96 cubic yards of material during the drilling of foundation shafts for the installation of a noise wall.

Indirect Effects

Indirect effects are caused by, or result from, the proposed action but occur later in time or outside of the area directly affected by the project. Indirect effects could occur within the entire 1,530 acre action area. The proposed project may result in indirect impacts to karst invertebrate habitat from surface disturbances such as vegetation removal, which may result in alterations in nutrient input and outflow and the introduction of invasive species. Other indirect effects to karst invertebrate habitat may occur within and adjacent to the project area due to the placement of impervious cover (bridge decks, roadway surfaces, etc.) which could increase chemical runoff or erosion and alterations in surface and subsurface drainage that may result in short- and long-term changes to temperature and moisture regimes in karst habitat.

Changes in the physical environment beneath a newly constructed road can create edge effects that extend beyond the construction timeframe. One of the edge effects is the reduction in water vapor transport into and out of the natural environment caused by the addition of the impervious surfaces of roadways. Natural surfaces, especially those with vegetation, use heat energy for evapotranspiration of water, effectively cooling themselves, while roadways store heat energy, raising the surface temperature of the roadway, and raising the temperature and lowering the humidity of the area immediately adjacent to the roadway (Barnes et al. 2012). Roadway materials, such as dark asphalt pavement, are thermally conductive, meaning they have the ability to absorb more heat and rapidly move it into the ground beneath the road surface. Heat stored by roadways is released at night, after the sun has gone down, creating a heat island when compared with surrounding soil or vegetation (Trombulak and Frissell 2000). Roadway heat islands exacerbate subsurface impacts to temperature and moisture by perpetuating drying conditions.

Indirect impacts due to future degradation of groundwater quality entering subsurface features resulting from roadway runoff contaminated with increased sediment and hazardous materials from accidental spills and vehicle collisions may also impact subsurface karst invertebrate habitat. Temporary and permanent BMPs, such as silt fence, rock berms, and detention ponds implemented in accordance with the project's SW3P and Multiple Separate Storm Sewer System (MS4) compliance documents are intended to mitigate for these impacts both during construction and for the duration of the facility's operation.

These actions may result in take of listed karst invertebrates, in the form of harm, due to habitat degradation from short- and long-term changes to temperature, humidity, and moisture regimes in karst habitat, groundwater contamination, changes in nutrient input, or an increase in invasive species. These habitat degradations could also result in harassment if they result in the disruption of essential behavioral patterns, such as breeding, feeding, or sheltering.

CHU 12 is heavily impacted by residential development within its boundaries. Alterations to the surface and subsurface drainage basins, and thus the PCEs of CHU12, have occurred during residential development due to the addition of impervious cover for construction of roads and houses, changes to the surface vegetation from native plants to lawn grass and ornamental flowers and shrubs, and subsurface alteration for utility installation and drainage. The adjacent limestone quarry, to the south, and significant urbanization surrounding CHU 12 also likely contribute to the lower quality of the CHU. The entrance to both caves in CHU 12 are at higher elevations than the adjacent ROW and their surface drainage basins do not extend into the ROW. Modifications to the ROW may indirectly affect the CHU PCEs due to hydrologic changes in nutrient flow or water quality through the subsurface drainage basins. However these potential effects are unlikely because the deepest mapped elevation of Ragin' Cajun Cave is at a slope of about five degrees below the final down-cutting grade of US 281 and the deepest mapped elevation of Hairy Tooth Cave is completely up gradient of the proposed project grade. It is unlikely that water or nutrients entering the subsurface as a result of downcutting within the US 281 ROW would maintain a shallow enough descent to affect either cave in the CHU.

<u>Species' response to the proposed action</u>

It is extremely difficult, if not impossible, to determine the response of *C. madla, R. exilis,* and *R. infernalis* to the proposed action. TxDOT has conducted surface surveys for karst habitat and investigated all potential karst features found in the pre-project survey. There are no known karst features within the proposed construction area that contain listed species. Since any karst habitat that would be affected by this action does not have a surface connection, there is no cave cricket foraging area to be altered by surface vegetation clearing. *R. exilis* exists in the two caves that occur in CHU 12, located in a residential subdivision adjacent to the US 281 ROW and within the project action area. The surface drainage basins for both caves are at higher elevations than the proposed project, therefore, they would not be altered or affected by the proposed project, either directly or indirectly. The subsurface drainage basins are not currently known, so it may be possible that *R. exilis* could be indirectly affected if project actions modify nutrient and water inputs or introduce contaminants into the subsurface drainage basins.

If any karst habitat is encountered during excavation or roadway construction, all work would be halted with a 50 foot diameter surrounding the void entrance and the onsite Professional Geoscientist (PG) would investigate the void to determine if it karstic in nature. If it is, a biologist holding a Service issued 10(a)(1)(A) scientific collecting permit would inspect the void to determine if the feature contains habitat for karst invertebrate species. If karst invertebrate habitat is present, TxDOT would attempt to avoid or minimize additional impacts to the feature and permanently close the feature to prevent further degradation. If the feature must be destroyed, incidental take associated with that activity is covered in this BO. If any other listed species are encountered that have not been provided take coverage in this opinion, TxDOT must halt construction and immediately reconsult.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

There are no other reasonably foreseeable future federal actions within the action area that would potentially affect *C. madla, R. exilis,* or *R. infernalis*. However, TxDOT estimates that it is reasonably foreseeable for an additional 522 acres within the action area to be developed by 2035. These developments include approved subdivisions with an approved Master Development Plan or other areas considered likely for development if other infrastructural improvements are implemented. Any private actions which would take listed karst invertebrates would likely need a section 10 Incidental Take Permit for their development, in order to avoid section 9 take violations.

Conclusion

C. madla, R. exilis, and *R. infernalis* are known to occur in areas of suitable karst habitat located in the Stone Oak KFR of Bexar County. All existing known karst features within the action area have been surveyed for the presence of listed karst invertebrates. It is unknown if there are any additional karst features within the action area, although the presence of additional karst features is likely. If karst features are present, it is also unknown if they are occupied by *C. madla, R. exilis,* and/or *R. infernalis.* If these species are present within karst features discovered during project construction, take of the species in the form of harm or harassment would likely occur.

Although TxDOT cannot eliminate the possibility of affecting karst invertebrates, they have minimized the effects to the maximum extent possible for this project. Therefore, after reviewing the current status of *C. madla, R. exilis,* and *R. infernalis*, the environmental baseline for the action area, the effects of the proposed US 281 improvement project, and the cumulative effects, it is the Service's biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of *C. madla, R. exilis,* and *R. infernalis,* nor result in the adverse modification or destruction of designated CH, for the following reasons:

15. The maximum amount of surface habitat that would be altered for this project is about 447 acres, of which about 100 acres are already cleared or impervious cover. The proposed project would convert an additional 98 acres to impervious cover and add 172 acres of cleared vegetation. The amount of surface habitat that would be directly affected is less than one third of the action area (29%) and only a small fraction of the potential habitat (Karst Zones 1 and 2) in the Stone Oak KFR.

16. Any new karst features affected by this project are currently unknown and are not part of the baseline populations of *C. madla, R. exilis,* and *R. infernalis*. Therefore, impacts to karst features in the action area, if they contain these species, would not decrease the baseline of the *C. madla, R. exilis,* and *R. infernalis* populations or reduce the potential for recovery.

17. The closest known location for *R. infernalis* is 1.7 miles to the west and it is not known if this species occurs within the action area. *R. infernalis* is known from at least 39 caves in Bexar County. The closest known location for *C. madla* is seven miles west in Camp Bullis. There are at least 22 caves in Bexar County that contain *C. madla*. *R. exilis* is known from two caves in the projects action area, Hairy Tooth, located about 1,570 feet from the edge of the ROW, and Ragin Cajun, located about 1,160 feet from the edge of the ROW, both located in CHU 12, which is also located in the action area. Although neither of these caves would be directly affected by the project, they may be indirectly affected if runoff or nutrient flow into the caves is altered to the point that it results in changes to the temperature, humidity, or nutrients in the caves. *R. exilis* is known from at least 53 caves in Bexar County.

18. The estimated amount of take is based on the amount of surface habitat to be directly impacted and a 500 foot buffer area which could be indirectly affected (1,530 acres total); however, if no previously undiscovered karst voids present beneath the action area contain *C. madla, R. exilis* and/or *R. infernalis*, no incidental take would occur. Take is only likely to occur within a fraction of the 1,530 acre action area, however due to the inability to detect precisely where take may occur due to the subterranean nature of karst habitat and species, take is being provided over the entire action area acreage of the project.

19. Only a small area 0.023 acre of CHU 21 is located within the ROW and would be directly affected by vegetation removal and downcutting associated with the project. This small area is likely not contributing to the conservation value of the constituent elements of CH due to being outside of the surface drainage basins of the two caves and at a generally higher elevation than the subsurface drainage basins. And although a portion of CHU 12 is within the action area of the project, the area is already disturbed by residential development, including roads and other infrastructure. There will be no, or minimal, impacts the trogloxene foraging areas, alterations in the nutrient input or outflow, or long-term changes in surface drainage patterns for either cave,

therefore, the project would not significantly diminish the conservation value of the PCEs contributing to the survival and recovery of *R. exilis*.

20. The purpose of the project is to improve traffic flow on this section of US 281. The water quality BMPs to be put into place before construction begins would help to treat existing roadway runoff that may be contaminating the surface or subsurface drainage basins of any underlying karst features that may be present.

The conclusions of this BO are based on full implementation of the project as described in the "Description of the Proposed Action" section of this document, including any Conservation Measures that were incorporated into the project design.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include death or injury to a listed species, or significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be undertaken by TxDOT, as appropriate, for the exemption in section 7(o)(2) to apply. TxDOT has a continuing duty to regulate the activity covered by this incidental take statement. If TxDOT (1) fails to assume and implement the terms and conditions or (2) fails to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, TxDOT must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

Amount or Extent of Take Anticipated

It is anticipated that incidental take of *R. infernalis, R. exilis* and *C. madla* would be difficult, if not impossible, to detect and quantify due to their extremely small size and subterranean, often inaccessible, karst habitat. The presence of these species is rarely known unless observed in their natural karst environment. And as previously discussed, occupied karst features in the action area are often undetectable until they are exposed from surface disturbing activities. Because of this, a precise mechanism for predicting the number of individuals that may actually be taken by the proposed project is not able to be calculated or estimated. Due to these factors, the extent of incidental take would be equated to the action area, where direct or indirect effects could occur. The incidental take of all *C. madla, R. exilis* and *R. infernalis* in any karst features underlying the 1,530 acre action area, in the form of harm or harassment, may occur as a result of this proposed project.

Effect of the Take

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to jeopardize the continued existence of *C. madla, R. exilis* and *R. infernalis*. The Service also determined that the proposed project would not result in destruction or adverse modification of designated CH within CHU 12 for *R. exilis*.

Reasonable and Prudent Measures

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize impacts of incidental take of *C. madla, R. exilis* and *R. infernalis*:

21. TxDOT must fully implement the Voluntary Conservation Measures proposed in their BA for this project.

22. TxDOT must provide information and training to all employees and contractors working on the project on the measures proposed to avoid impacts to karst invertebrate and golden cheeked warbler habitat.

23. TxDOT must monitor the take of *C. madla, R. exilis,* and *R. infernalis,* using acreage impacted by the project as a proxy, and provide periodic monitoring reports to the Service.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the TxDOT must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

24. TxDOT has proposed a number of Conservation Measures, listed in the BA and the "Description of the Proposed Action" section of this document. TxDOT's proposed Conservation Measures are incorporated as reasonable and prudent measures by reference and must be implemented, as proposed, in conjunction with this project. Failure to implement the proposed conservation measures would constitute a change in the proposed action, triggering the need to reinitiate the consultation per the requirements of 50 CFR 401.16(c).

25. TxDOT must hold a pre-construction meeting with its employees and contractors working on this project. TxDOT must provide specific instruction on the implementation of TxDOT's proposed Conservation Measures and the Service's Reasonable and Prudent Measures, included in this Incidental Take Statement. Instructions specific to the contractor(s) related to implementation of TxDOT's proposed Conservation Measures and the Reasonable and Prudent Measures described herein must be documented in writing. TxDOT is ultimately responsible for informing anyone working on this project of these requirements.

26. TxDOT must monitor and report to the Service the amount of incidental take that occurs in association with this project. This must be done through sufficient on-site inspections to determine if construction related impacts have or would occur outside of the action area, as described in this BO. The monitoring reports must include a summary of construction actions implemented during the previous six month period, any unanticipated actions or delays in project completion, and any known incidental take that has occurred (disturbance of karst invertebrate habitat) and the reasons for that take. Monitoring reports must be submitted in accordance with the timelines proposed in TxDOT's project monitoring and reporting Conservation Measure.

The Service believes that it would be impossible to detect and quantify the number of individuals that may be incidentally taken as a result of the proposed project due to their extremely small size and the inaccessibility of their karst habitat. Therefore, incidental take is authorized for all *C. madla, R. exilis,* and *R. infernalis* occupying karst habitat within the boundaries of the 1,530 acre action area. The incidental take would be in the form of harm or harassment. The Reasonable and Prudent Measures, with their implementing Terms and Conditions, are designed to minimize the impact of the incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded (i.e., the amount of ground disturbance activities exceeds 447 acres or overall area of affect exceeds 1,530 acres), such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. TxDOT must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

Conservation Recommendations

Section 7(a)(1) of the Act directs TxDOT, as well as other federal agencies, to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service has no conservation recommendations for TxDOT concerning the conservation of listed karst invertebrate species at this time. In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations by TxDOT.

Reinitiation Notice

This concludes the Service's formal consultation on the action outlined in TxDOT's formal consultation request. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) the project is not completed within five years of the date of this BO; (3) new information reveals the agency action that may affect listed species or critical habitat in a manner, or to an extent, not considered in this opinion; (4) the agency action is subsequently modified in a manner that causes an effect to the listed species or CH not considered in this opinion; or (5) a new species is listed or CH is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease immediately pending reinitiation.

Sincerely,

Cliff Schleusner
Acting Field Supervisor
Texas Coastal Ecological Services Field Office

cc: Barrlynn West, TxDOT San Antonio District, San Antonio, TX (electronic)
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BIOLOGICAL ASSESSMENT

US 281
FROM LOOP 1604 TO BORGFELD DRIVE
BEXAR COUNTY, TEXAS

Supporting FHWA-TX EIS-11-02-D
Control Section Job Number: 0253-04-138, 0253-04-146

December 30, 2014

The environmental review, consultation, and other actions required by applicable Federal environmental laws for this project are being, or have been, carried-out by TxDOT pursuant to 23 U.S.C. 327 and a Memorandum of Understanding dated December 16, 2014, and executed by FHWA and TxDOT.

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Chapter 1
Project Overview

1.1 FEDERAL NEXUS

This Biological Assessment (BA) has been prepared by the Texas Department of Transportation (TxDOT) and the Alamo Regional Mobility Authority (Alamo RMA) to address the proposed action in compliance with Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended. Proposed improvements to U.S. Highway 281 (US 281) (Loop 1604 to Borgfeld Drive) would be partially funded with federal sources and therefore constitute a federal action. This BA follows and draws extensively from the April 2013 Draft Environmental Impact Statement (Draft EIS) (Federal Highway Administration [FHWA] et al. 2014) prepared by the FHWA, TxDOT and the Alamo RMA in cooperation with the U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service (USFWS).

Specifically, this BA addresses potential direct and indirect effects to the Madla Cave meshweaver (*Cicurina madla*), two ground beetles (*Rhadine exilis* and *R. infernalis*), and the Golden-cheeked Warbler (*Setophaga chrysoparia*) by the proposed project as required for consultation with the USFWS. Specific project design elements that avoid or minimize adverse effects of the proposed project on listed species and/or critical habitat are also identified.

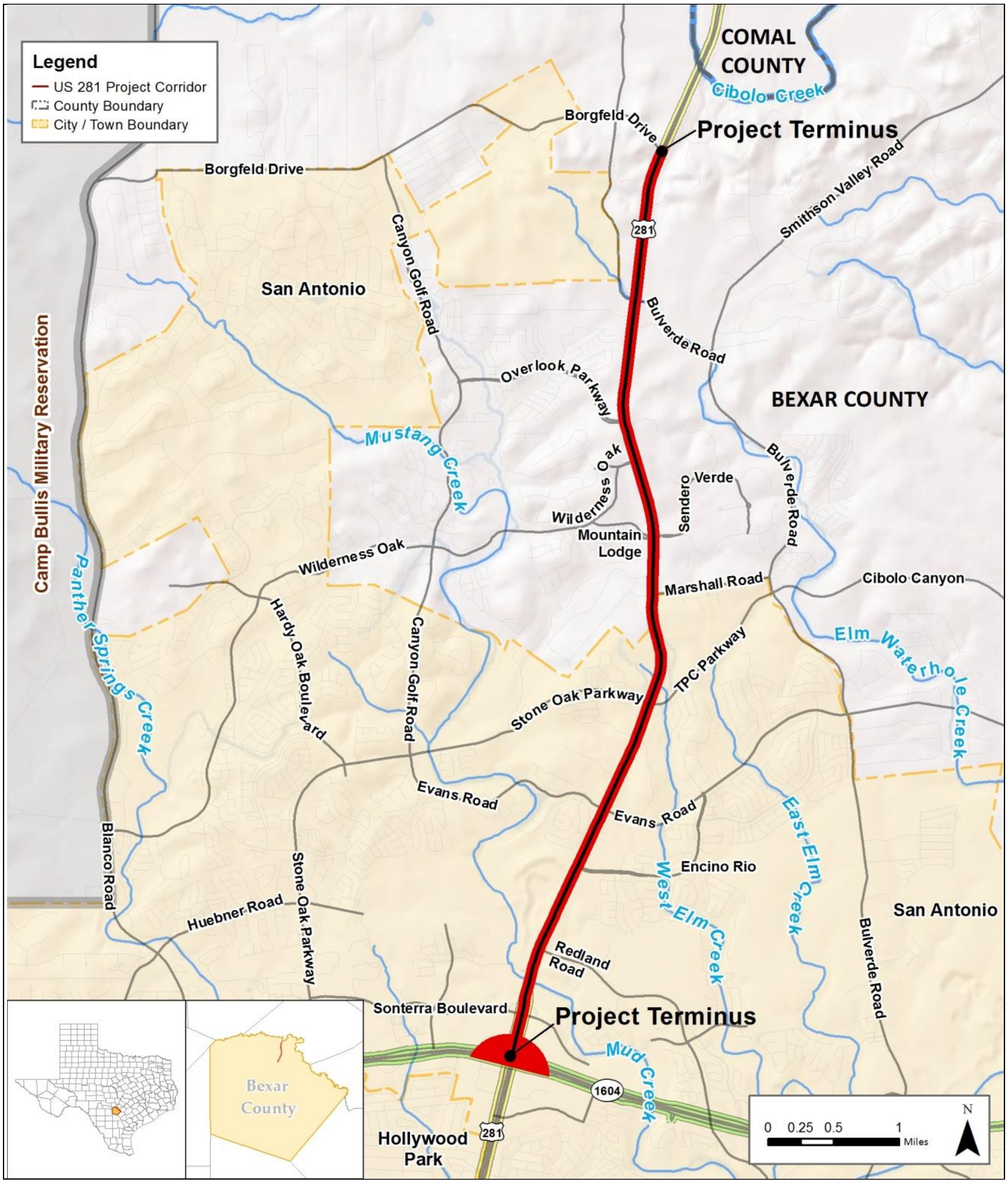
1.2 PROJECT DESCRIPTION

The proposed project includes improvements to US 281 along a 7.3 miles stretch from Loop 1604 to just north of Borgfeld Drive within the city of San Antonio, and to the north of Borgfeld Drive in northern Bexar County, Texas (**Figure 1-1**). Four direct connector ramps that comprise the northern half of the US 281 interchange with Loop 1604 are included in the proposed improvements. Control section job (CSJ) 0253-04-146 is from Loop 1604 to Stone Oak Parkway and would expand US 281 to a six-lane expressway (four non-toll lanes and two managed lanes) and non-toll northern direct connectors at Loop 1604 (**Figure 1-2**). From Loop 1604 to approximately Stone Oak Parkway, the general purpose/managed lanes would be situated between partial access-controlled outer lanes, also known as frontage roads. CSJ 0253-04-138 is from Stone Oak Parkway to the Bexar/Comal County line and would ultimately expand US 281 to an eight-lane expressway (four managed lanes and four non-toll lanes) (**Figure 1-3**). From approximately Stone Oak Parkway to Borgfeld Drive, the main lanes would be managed and the outer lanes would function as US 281.

Grade separations would be provided at Sonterra Boulevard, Redland Road, Encino Rio, Evans Road, Stone Oak Parkway, Marshall Road, Wilderness Oaks, Overlook Parkway, Bulverde Road, and Borgfeld Drive to allow the general purpose/managed lanes to pass uninterrupted over the cross streets; thus, the general purpose/managed lanes would not intersect directly with these local streets. Schematic drawings of the proposed project are included in **Appendix A**. The proposed right-of-way (ROW) would typically be 400 feet wide. The proposed project requires approximately 79 acres of additional ROW.

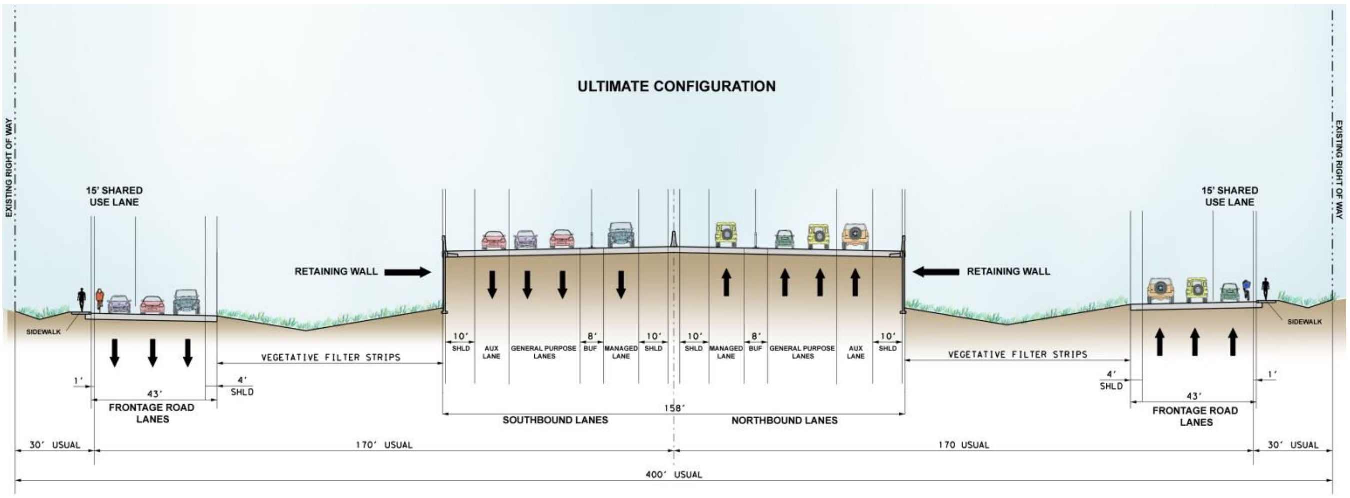
The proposed project has independent utility without the benefits of the implementation of other programmed transportation improvements. The project improvements would function as a usable roadway, would not require implementation of other projects to operate, and would not restrict consideration of alternatives for other foreseeable transportation improvements.

Figure 1-1: US 281 project corridor



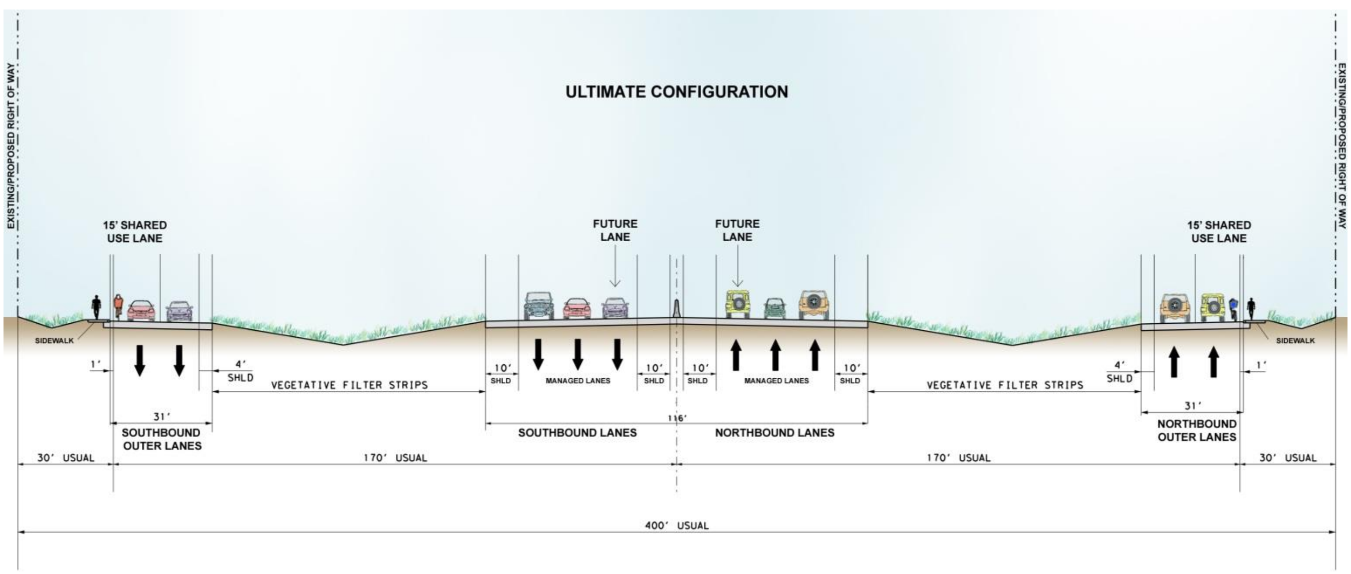
Source: US 281 EIS Team 2011.

Figure 1-2: Proposed project typical section south of Stone Oak Parkway



Source: US 281 EIS Team 2014.

Figure 1-3: Proposed project typical section north of Stone Oak Parkway



Source: US 281 EIS Team 2014.

1.3 CONSTRUCTION

1.3.1 Project Timeline and Sequencing

The project is anticipated to receive a Record of Decision (ROD) on the Final EIS in summer 2015. If a Build Alternative is selected, construction could begin in spring 2016 and be completed in the fall of 2018. Sequencing of construction is unknown at this time.

1.3.2 Construction Access and Staging

Traffic would remain on existing US 281 during the initial construction. The construction phasing would begin with preparation of the ROW, followed very closely by stormwater pollution prevention device installation. Drainage structures and stream bridges would follow. Frontage roads/outer lanes would be constructed next to provide local property access and cross street connections. Traffic would then be shifted over to the new frontage roads/outer lanes and the existing US 281 would be removed. The main lanes and remaining bridge structures would be constructed as well as the connection to the proposed VIA Park and Ride facility. The direct connector bridges/ramps from Loop 1604 to US 281 would be built integral with the main lane construction. The water quality treatment would be fully constructed and permanent vegetation established as part of the final construction.

Subsurface excavation would be necessary to construct bridge and roadway sections. Subsurface excavation for bridge supports will include footings and drilled shafts with depths up to 50 feet. Cuts for roadway excavation will range from zero to 23 feet in depth. Some residential areas will be protected by noise walls, whose foundations will require subsurface excavation up to 12 feet in depth. Additional excavation would also be required for project utilities and stormwater drainage with depths ranging from 10 to 15 feet.

Subsurface disturbance will also occur as a result of the removal and replacement of pavement. The existing pavement structure on US 281 primarily consists of a graded limestone rock base (4 inches thick) as the bottom layer and an asphalt stabilized rock base (5 inches thick) as the middle layer with an asphaltic riding surface (3 inches thick). During the removal of pavement, the asphaltic surface course is removed separate from the underlying base with a pavement milling machine designed to grind and pick up the asphaltic surface, which is loaded into a truck to be recycled. The asphalt stabilized base would also be removed using the same method. The salvaged material is then hauled to a stockpile location where it can be recycled into new hot mix asphaltic pavement or transferred to others for use as a fill material. The graded limestone rock base is normally removed with a front-end loader or excavator and loaded immediately into a truck for delivery to a stockpile or to a location elsewhere on the project needing fill material. If the contractor is not required to remove the asphaltic material using a milling machine and the size of the material is not a requirement for recycling, then the asphaltic material may be removed with a front-end loader or excavator that will scoop the material up in large chunks and then dump into a truck for transfer to an off-site location for other purposes. When salvaging the material, the contractor will not remove material deeper than the pavement structure because of the depreciation of the salvaged material if mixed with lower quality earthen material. After the pavement is removed, then the remaining earthen surface would be scarified and reshaped usually with the use of a motor-grader. The surface is then readied to receive additional fill material by disking before being compacted. Normal depth of scarifying and reshaping of material is less than 12 inches.

Construction access and staging would likely occur within the current project area and existing ROW. Additional details on access and staging will not be available until the design is finalized and a construction contractor is chosen; however, all project specific locations (PSLs), such as staging areas will be located at least 300 feet from any potential listed species habitat unless it has been surveyed in accordance with USFWS protocols to determine that the habitat is not occupied. Ultimately, the contractor will be responsible for locating construction yards and any other laydown areas from private owners. Several sites are commercially available adjacent to the proposed roadways. Another option for the contractor is to locate in the proposed roadway areas within the existing ROW until such time that the area would be needed for the completion of the roadway.

1.3.3 Post-Project Site Restoration

All disturbed areas will be re-vegetated according to TxDOT's standard practices for urban areas and to the extent practicable, in compliance with Executive Order 13112 on Invasive Species and the Executive Memorandum on Beneficial Landscaping.

1.3.4 Operations and Maintenance

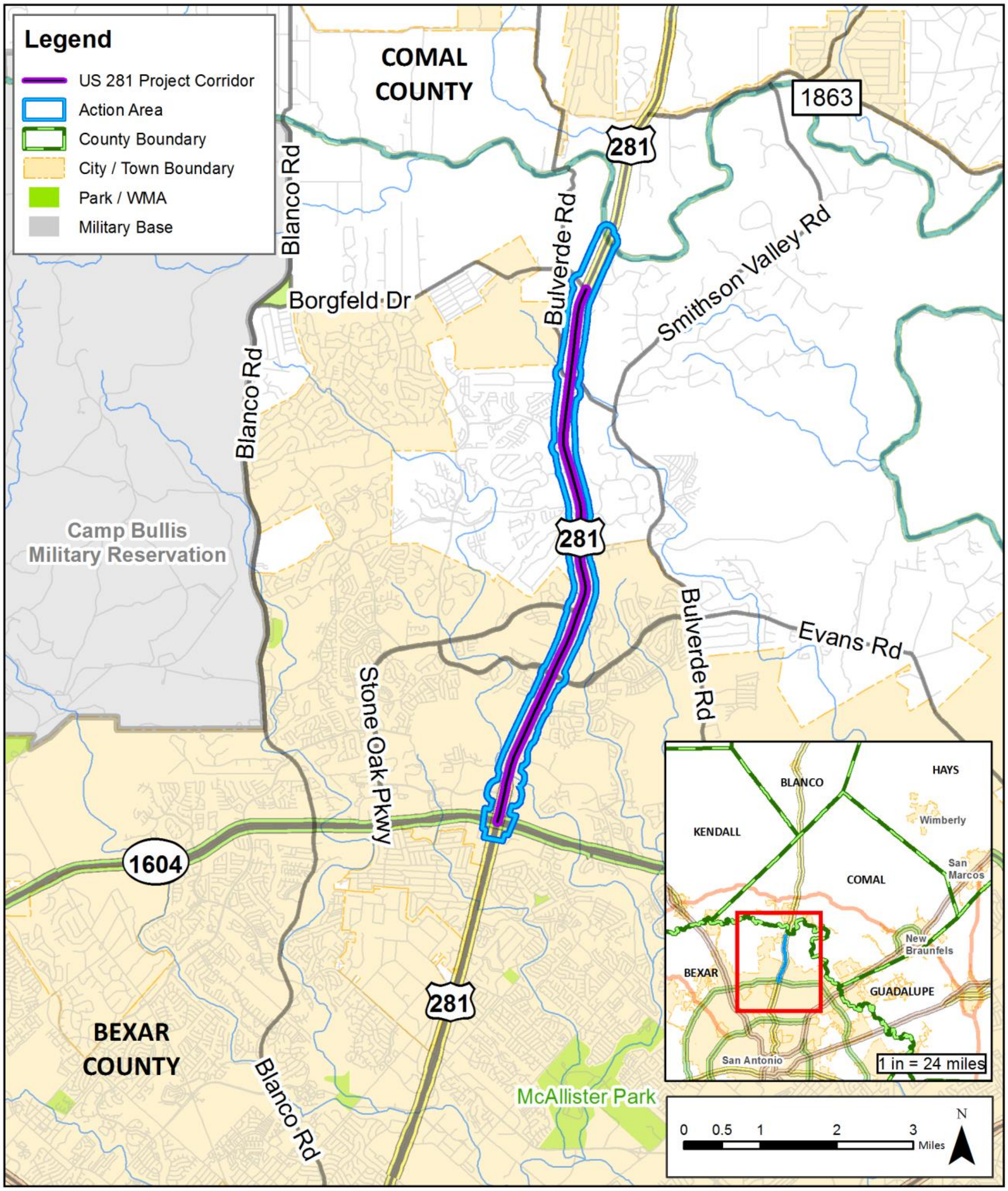
TxDOT's standard practices for roadway operations and maintenance will be implemented following the completion of post-project site restoration activities.

1.4 PROJECT AREA AND ACTION AREA

This BA refers to both the project area and the action area. The project area is defined as the existing and proposed ROWs and immediately surrounding area along US 281 between Loop 1604 and Borgfeld Drive. US 281 project area, which includes the existing and proposed ROW and an area extending 500 feet outward from the existing and proposed ROW to capture disturbance from construction activities that have the potential to extend beyond the project footprint. For this project, this includes areas where project activities could potentially directly or indirectly affect federally listed threatened and endangered species. The action area covers 1,406 acres, approximately 2.2 square miles, in northern Bexar County (**Figure 1-4**). The geological and ecological settings of the project area and action area lend themselves to a broad geographic focus area due primarily to the sensitivity and connectivity associated with karst topography and Edwards Aquifer resources.

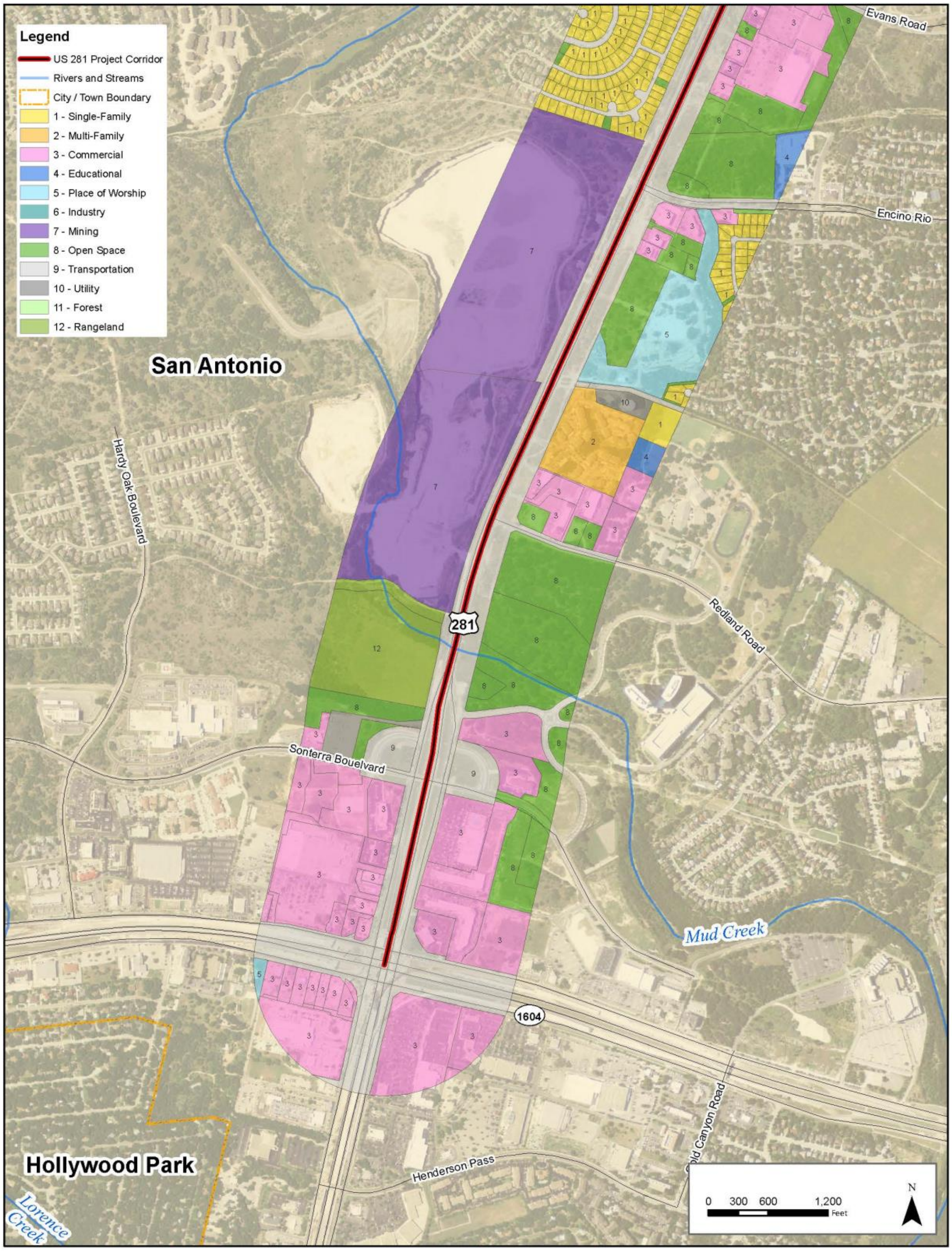
Northern Bexar County's existing land development pattern can be described as suburban residential development, which is spread somewhat uniformly over a large area with commercial services concentrated along major roadways like US 281 and Blanco Road. Existing land uses in and near the project area are shown in **Figure 1-5a** through **Figure 1-5e** beginning at Loop 1604 and US 281 in the south of the study area moving in a north-northeast direction. In general, the land uses adjacent to the US 281 project corridor south of Stone Oak Parkway include a quarry, commercial centers, multi-family residential development, and single-family residential development. North of Stone Oak Parkway, the developed uses tend to be smaller commercial properties adjacent to US 281 with single-family residential set back from the ROW.

Figure 1-4: Action Area



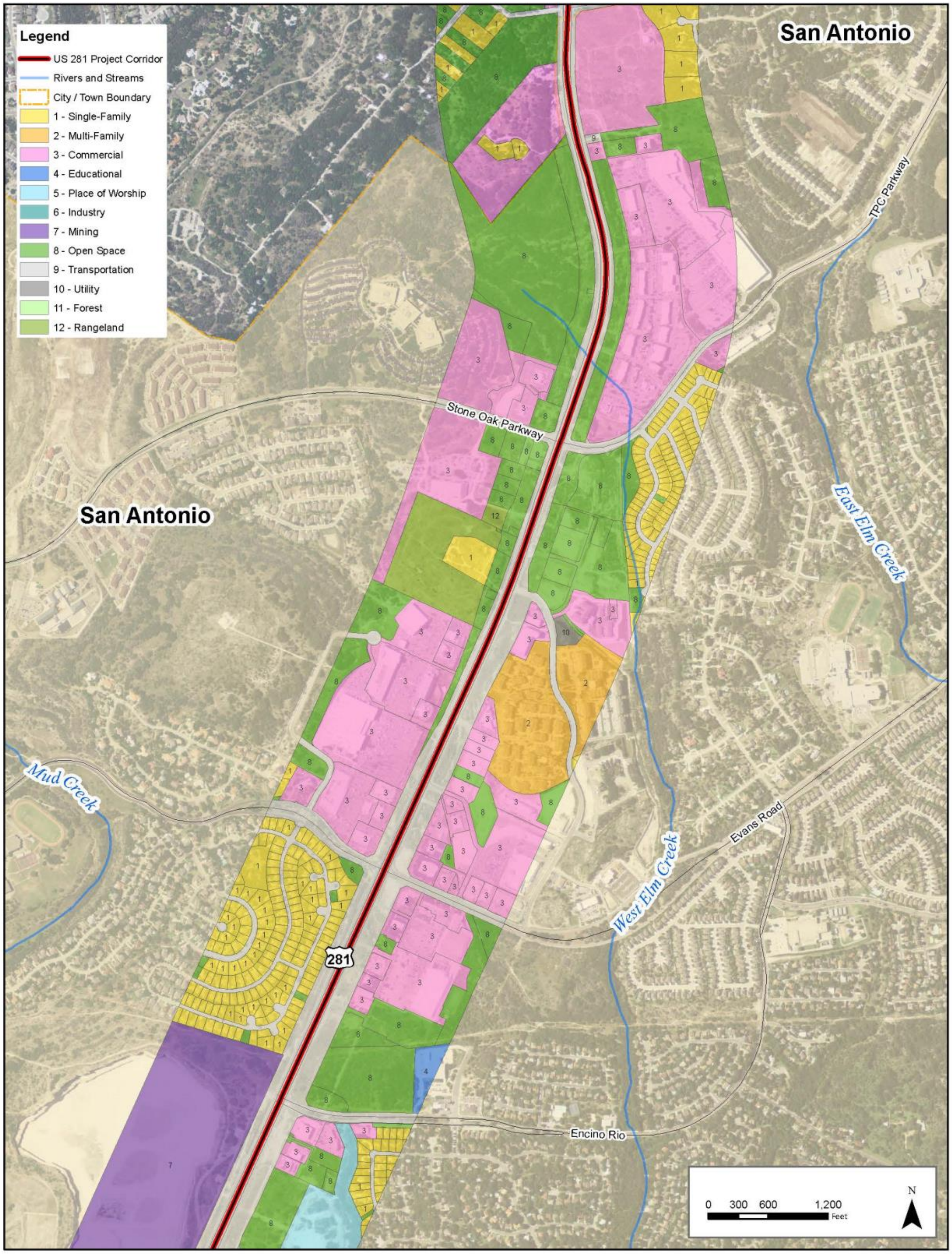
Source: US 281 EIS Team 2014 (December).

Figure 1-5a: Existing land use within the project area



Source: Bexar Appraisal District 2010; US 281 EIS Team 2014 (April).

90 Figure 1-5b: Existing land use within the project area



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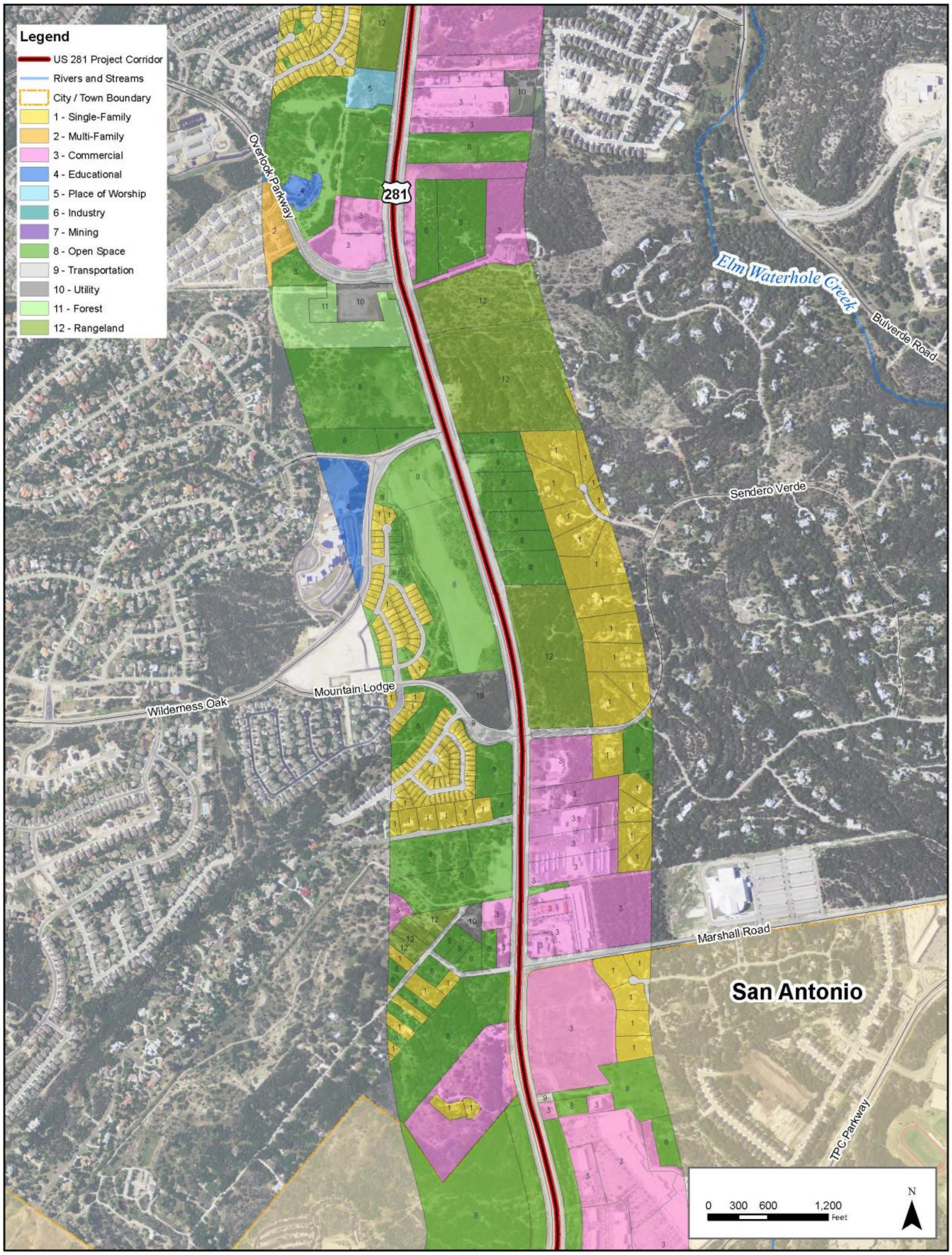
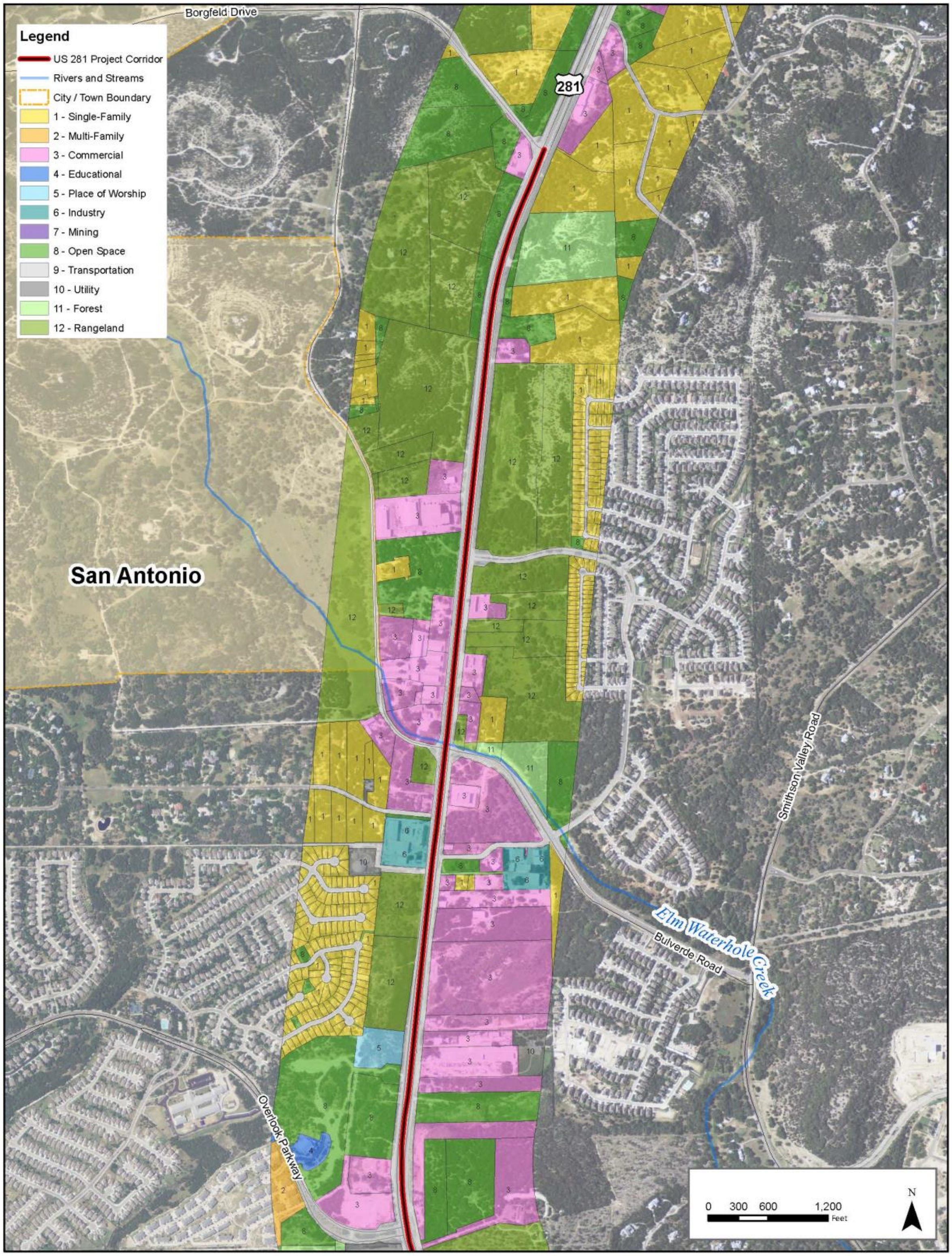
92 Source: Bexar Appraisal District 2010; US 281 EIS Team 2014 (April).

Figure 1-5c: Existing land use within the project area



Source: Bexar Appraisal District 2010; US 281 EIS Team 2014 (April).

96 **Figure 1-5d: Existing land use within the project area**



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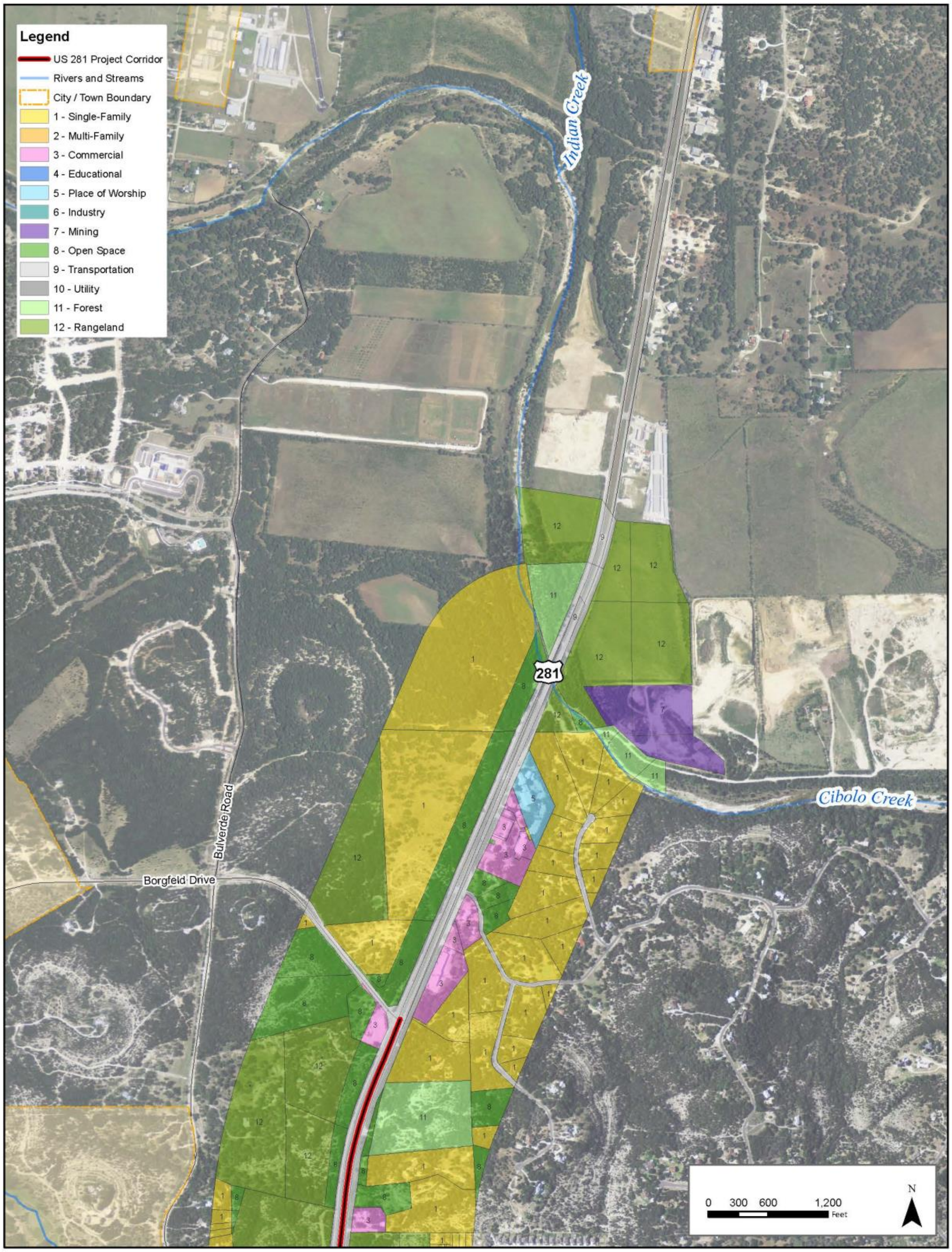
98 Source: Bexar Appraisal District 2010; US 281 EIS Team 2014 (April).

99 **Figure 1-5e: Existing land use within the project area**



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101 Source: Bexar Appraisal District 2010; US 281 EIS Team 2014 (April).

1.5 CONSULTATION HISTORY

The US 281 EIS was initiated by the Alamo RMA, TxDOT, and FHWA in July 2009, and a Draft EIS was published and circulated for public review in April 2013 (FHWA et al. 2014). The Alamo RMA was also working on a Loop 1604 EIS. Given their combined focus upon these two projects at that time, some initial USFWS consultations involved team members from both projects. This is reflected in some entries in the consultation history below.

Table 1-1 below provides a summary of coordination between USFWS, Alamo RMA, TxDOT, and the US 281 EIS Team.

Table 1-1: Coordination Between USFWS, Alamo RMA, TxDOT, and the US 281 EIS Team

March 24, 2009	Initial coordination meeting with Alamo RMA, Blanton & Associates, and USFWS regarding endangered bird surveys. Agenda included habitat assessment methodology, presence/absence survey methodology, and future field visit coordination for habitat assessment review.
April 10, 2009	Field visit with Alamo RMA, Blanton & Associates, Hicks & Company, and USFWS to US 281 project areas to confirm Golden-cheeked Warbler (GCWA) and Black-capped Vireo (BCVI) habitat assessment results and make adjustments as necessary.
Jan. 22, 2010	US 281 EIS Threatened and Endangered Species Meeting – held at Alamo RMA and attended by Alamo RMA, Hicks & Company, Jacobs, USFWS, and Zara Environmental. Agenda included project description, previous studies conducted in corridor, karst and avian species surveys underway and proposed species list for consideration in potential §7 consultation, indirect and cumulative impact assessment approach and resource study areas.
Sept. 15, 2010	Combined Loop 1604 EIS and US 281 EIS USFWS Coordination Meeting – held at Government Canyon USFWS office with Alamo RMA, Blanton & Associates, FHWA (phone conference), Hicks & Company, Jacobs, Michael Baker, TxDOT Environmental Affairs Division (ENV) (phone conference), USFWS, and Zara Environmental. Agenda included listed species survey status, §7 consultation initiation, Draft EIS status, pending karst critical habitat unit (CHU) review status, litigation status, and next steps.
Oct. 18, 2010	Letter sent by Alamo RMA to USFWS requesting concurrence that two years of surveys with negative findings for GCWA on US 281 is sufficient to demonstrate absence.
March 1, 2011	Combined Loop 1604 EIS and US 281 EIS USFWS Coordination Meeting – held at Jacobs San Antonio office with Alamo RMA, Blanton & Associates, FHWA (in person and phone conference), Hicks & Company, Jacobs, Michael Baker, TxDOT ENV (phone conference), USFWS, and Zara Environmental. Agenda included listed species survey status, §7 consultation initiation, pending karst CHU review status, litigation status, BE and Draft EIS schedules and status, remaining species surveys, and next steps.
May 11, 2011	USFWS letter to Alamo RMA concurring that two years of survey with negative findings for GCWA on US 281 is sufficient to demonstrate absence. Stipulation provided that survey might have to be updated if construction was not initiated within three years. Survey conducted as required in 2014 breeding season.

March 13, 2014	Meeting to discuss preferred alternative for US 281. Attended by TxDOT ENV and San Antonio District, Alamo RMA, USFWS, FHWA, Texas Parks and Wildlife Department (TPWD), City of San Antonio (COSA), Edwards Aquifer Authority (EAA), Texas Commission on Environmental Quality (TCEQ), San Antonio-Bexar County Metropolitan Planning Organization (SA-BC MPO), and VIA Metropolitan Transit.
Sept. 5, 2014	Letter sent to USFWS by TxDOT initiating informal consultation supported by a Biological Evaluation document with "may affect, not likely to adversely affect" calls for *C. madla*, *R. exilis*, *R. infernalis*, and the Golden-cheeked Warbler.
Sept. 8, 2014	Communication from USFWS to TxDOT indicating that USFWS did not find support for "may affect, not likely to adversely affect" calls for *C. madla*, *R. exilis*, and *R. infernalis* in the Biological Evaluation document.
Sept. 23, 2014	US 281 Karst Resources Meeting - Held at TxDOT ENV offices and attended by TxDOT ENV and San Antonio District, Alamo RMA, USFWS, FHWA, Jacobs, and Zara Environmental. Prior to the meeting USFWS, TxDOT, and Zara personnel toured CHU 12 and looked at voluntary conservation measures performed at Power Pole Hole. USFWS requested additional information to justify a "may affect, not likely to adversely affect" call based on the context and sensitivity of project impacts.
Jan. 5, 2015	TxDOT submitted the BA and initiated formal consultation with the USFWS.

Source: US 281 EIS Team 2014.

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Chapter 2

Federally Listed Species and Critical Habitat

The following sections describe the biological and physical conditions in the action area, species/critical habitat considered, status of the species within the action area, and a summary of listed species surveys conducted in the project area.

2.1 BIOLOGICAL AND PHYSICAL CONDITIONS IN THE PROJECT AREA AND ACTION AREA

The US 281 Corridor Project area traverses karstic limestone. The portion of the Edwards Plateau ecological region where the project area and, to a lesser extent, the action area, are located has been undergoing a conversion from native rangeland to a more suburban landscape. Overview level information regarding these resources is provided below.

2.1.1 Groundwater and Surface Water

The US 281 project corridor crosses the Edwards and Trinity Aquifers, which supply water to millions of people in central Texas. The actual area of consideration for groundwater expands beyond the narrow ROW construction corridor along US 281 because of the nature and extent of these aquifers. The sensitive Edwards Aquifer Recharge Zone is found at the surface through much of this area. Much of the recharge to this aquifer is focused and channeled through several creeks that cross the outcrop areas. The remaining surface water flow eventually drains into the San Antonio River within Bexar County. Water wells or other hydrologic features that sustain habitat for aquifer species in the project area have the potential to experience rapid and concentrated contaminant impacts. The action area may also be impacted, although likely in a more diluted manner and over an extended time scale.

According to Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) panel numbers 48029C0277 E, 48029C0140 E and 48029C0130 E, the U.S. Geological Survey (USGS) 7.5-Minute Topographic Map Quadrangles (Bulverde, Camp Bullis, Castle Hills and Longhorn, TX quads), and field reconnaissance, the US 281 project corridor intersects thirteen stream crossings. The streams and/or tributaries include Mud Creek, West Elm Creek, Elm Waterhole Creek, and Cibolo Creek. Four springs and an off-channel pond were also identified during field work.

2.1.2 Karst Terrain

The US 281 project area is situated over a karst landscape. In this type of terrain, limestone bedrock is dissolved by mildly acidic rain and groundwater to create caves and sinkholes. The US 281 project area has seen significant development in recent years, particularly in the form of increased impervious cover due to commercial infrastructure and residential developments. This impervious cover tends to reduce water and nutrient input into cave passages and mesocavernous (humanly impassable) voids, which in turn has the potential to impact the habitats and species within them. In karst areas, water enters the subsurface at obvious cave entrances and seemingly plugged sinkholes, and also generally across the landscape. This general recharge occurs at the soil/bedrock interface via the semi-dissolved upper layer of limestone known as epikarst. These epikarstic portals lead into the mesocavernous zone and also introduce nutrients such as organic debris, roots, and micro-fauna. The existing impervious cover along the US 281 project corridor inhibits these processes by diverting water from natural paths of flow.

Some cave entrances along the US 281 project corridor have been destroyed. These include Tiny Town Sink, which was covered during widening of US 281 in the early 1970s (Veni 1988), and Voight Cave No. 1, which is in an area now covered by retail development. Other caves were impacted when they were intersected as a result of development activities, such as Power Pole Hole. This feature was intersected while drilling the foundation for a utility pole in 2007, at a depth of 3 feet. This void may have had a natural opening in the past that was covered either by shoulder grading activities or by sewer line installation along the US 281 project corridor. At some time during these activities a large quantity of recycled asphalt was dumped into the void. This cave is penetrated by small core holes into which copper ground rods for two power poles were inserted. A black tar-like material, possibly creosote, has dripped down into the cave through these holes. Both asphalt and creosote can be harmful to cave ecosystems. Prior to the establishment of required assessments for recharge features (by the TCEQ) and listed karst invertebrates (by the USFWS), there were no regulatory requirements to record or preserve caves. Cave entrances allow surface species such as bats, mice, porcupines, and cave crickets to enter the subsurface and thereby introduce energy in the form of organic materials from waste and decomposing animal matter. Other organic debris, such as leaf litter, is washed into cave entrances during rain events. The input of organic debris and moisture are crucial to subterranean ecosystems.

Several large quarries are adjacent to the US 281 project corridor. Given the observed density of cave entrances and karst features in the surrounding area and considering the depth to which these quarries have cut into the bedrock, these activities have likely resulted in the destruction of caves. Quarry Bat Cave was located in a quarry wall northwest of the intersection of US 281 and Sonterra Boulevard. It was reported by a helicopter pilot who witnessed bats flying out of it in May 2005. By 2010, aerial imagery indicated that the cave had been quarried away (Texas Speleological Survey [TSS] 2010). Cave-dwelling bat species nationwide have been severely impacted by a rapidly communicable fungal infection that causes the disease known as white-nose syndrome (WNS) (Lorch et al. 2011). Millions of bats have been killed in recent years by this disease in the northeastern U.S., resulting in catastrophic population declines, and is projected to lead to widespread extirpations over large parts of the geographic ranges of affected species (Thogmartin et al. 2013). As of August 2014, WNS was confirmed in 25 states, including Arkansas, and could soon spread to Texas, which makes any potentially adverse impacts to bat caves an immediate concern (USFWS 2014a).

A number of caves, verified karst features, and potential karst features (those not yet fully investigated) are known to occur within the US 281 project corridor. It is likely that additional caves or karst features would be revealed during construction of the project.

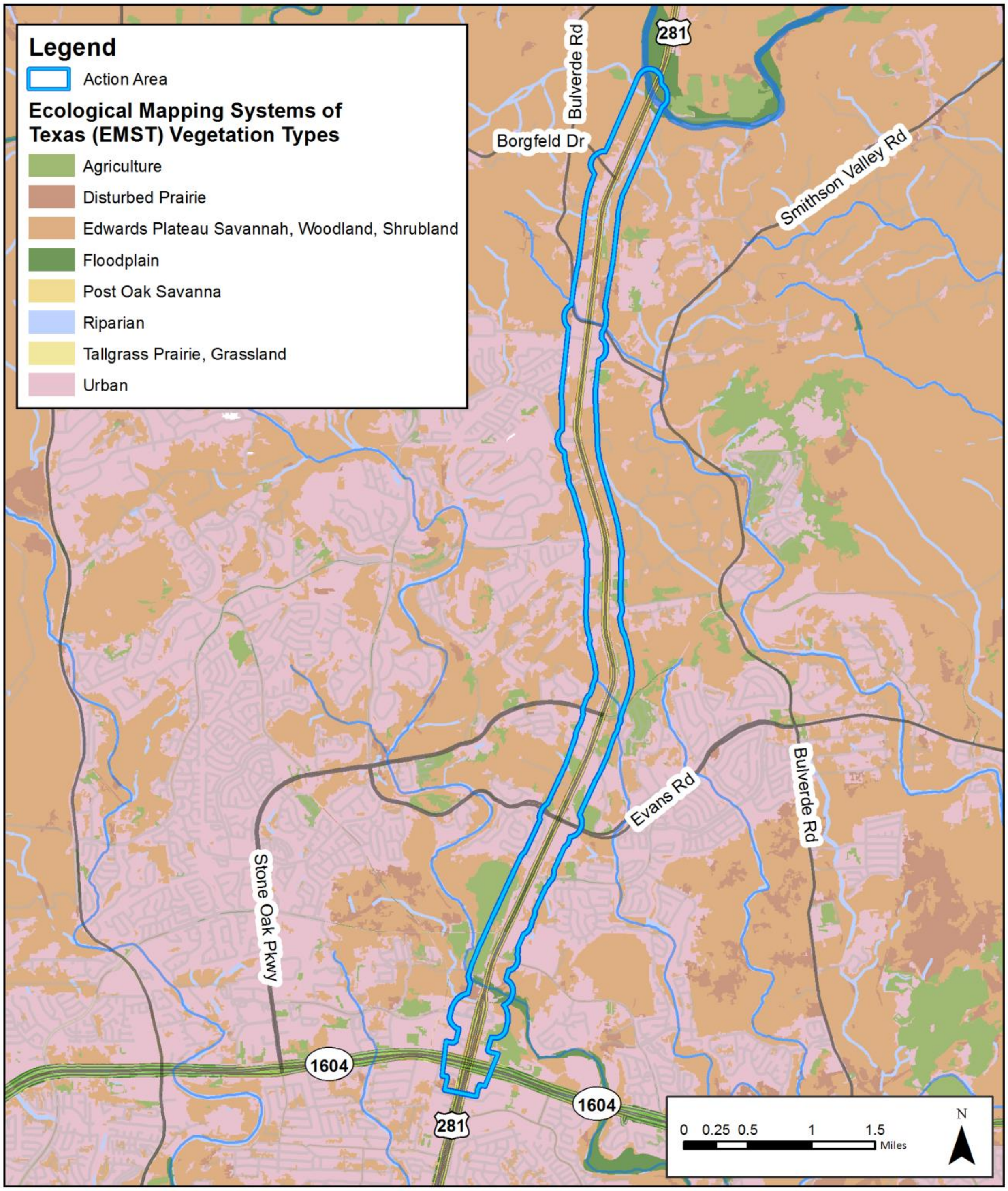
2.1.3 Vegetative Communities

A review of the Ecological Management Systems of Texas (EMST) data indicates that eight broad category vegetative communities occur within the action area (TxDOT 2013a). These broader categories include Agriculture, Disturbed Prairie, Edwards Plateau Savannah Woodland Shrubland, Floodplain, Post Oak Savannah, Riparian, Tallgrass Prairie Grassland, and Urban. **Figure 2-1** illustrates the vegetative communities within the action area.

The majority of the undeveloped or unmaintained portion of the project area is characterized Edwards Plateau Savannah Woodland Shrubland, Floodplain, Post Oak Savannah. This category is accounts for approximately 33 percent of the vegetation in the action area. Urban areas account for 45% of the action area, with areas dedicated to agriculture accounting for 10% of the action area. The remaining categories individually account for 5% or less of the action area.

Edwards Plateau Savannah Woodland Shrubland, Floodplain, Post Oak Savannah is mosaic of evergreen oak and juniper forests, woodlands and savannas over shallow soils or rolling uplands and adjacent upper slopes within the Edwards Plateau where limestone is present. The dominant woody species include plateau live oak (*Quercus fusiformis*) and Ashe juniper (*Juniperus ashei*), with much lesser amounts of Texas oak (*Quercus buckleyi*), Lacey oak (*Quercus laceyi*), sugar hackberry (*Celtis laevigata*), Texas ash (*Fraximus texensis*), cedar elm (*Ulmus crassifolia*), escarpment black cherry (*Prunus serotina* var. *eximius*), and Texas walnut (*Juglans microcarpa* var. *microcarpa*) (Elliot 2014). The understory of these areas are generally well developed with Ashe juniper limbs, vines, and various shrubs including the Texas persimmon (*Diospyros texana*), skunkbush sumac (*Rhus aromatic*), honey mesquite (*Prosopis glandulosa*), agarito (*Mahonia trifoliolata*), mountain laurel (*Sophora secundiflora*), prickly pear (*Opuntia* spp.) flameleaf sumac (*Rhus copallium*), elbow bush (*Fortetiera pubescens*), greenbrier (*Smilax bona-nox*), and grape (*Vitis* spp.). The average canopy coverage in these areas range from 50 to 90 percent and the height range was estimated to be 15 to 25 feet. The diameter-at-breast-height (dbh) ranged from 8 to 24 inches and an estimated average dbh of 15 inches. Upland areas contain mottes of plateau live oak within a grass dominated landscape, forming what has been referred to as a motte-savanna. Savanna grasses include little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), silver bluestem (*Bothriochloa laguroides* ssp. *torreyana*), Texas wintergrass (*Nassella leucotricha*), Indiangrass (*Sorghastrum nutans*), curlymesquite (*Hilaria belangeri*), big bluestem (*Andropogon gerardii*), purple threeawn (*Aristida purpurea*), and/or cedar sedge (*Carex planostachys*) (Elliot 2014). Herbaceous species are often dominated by the non-native grasses King Ranch bluestem (*Bothriochloa ischaemum* var. *songarica*).

Figure 2-1: Vegetative communities within the action area



Source: Simplified from the Ecological Mapping Systems of Texas (TxDOT 2013, TPWD 2010); US 281 EIS Team 2014 (December).

2.2 SPECIES CONSIDERED

Databases of sensitive species maintained by the USFWS and TPWD identified 25 federally listed threatened, endangered, or candidate species that may occur in Bexar County, including two plants, three mollusks, one crustacean, six arachnids, five insects, one fish, two amphibians and five birds. These species are listed in **Table 2-1** and discussed in further detail below the table; however, analysis of candidate species will not be carried forward past this section.

Table 2-1: Summary of Threatened and Endangered Species and Potential for Effect/Impact by the US 281 Corridor Project

Common Name	Scientific Name	Status	Potential Occurrence Within the Project Area and Effect/Impact Determination
Bracted twistflower	*Streptanthus bracteatus*	Candidate	Yes. Habitat for the *Streptanthus bracteatus* is found within the US 281 project area, yet no specimens were observed during on-site habitat assessments or avian surveys in 2009, 2010, or 2014. The US 281 Corridor Project ***may impact*** this species.
Texas wild-rice	*Zizania texana*	Endangered	No. This species is only known from the upper 1.6 miles of the San Marcos River in Hays County. The US 281 Corridor Project would have ***no effect*** on this species.
Golden Orb	*Quadrula aurea*	Candidate	No. There are no perennial streams within the project area, thus the US 281 Corridor Project would have ***no impact*** on this species.
Texas Fatmucket	*Lampsilis bracteata*	Candidate	No. The US 281 project area falls within the San Antonio River basin and is out of the range for this species, thus the US 281 Corridor Project would have ***no impact*** on this species.
Texas Pimpleback	*Quadrula petrina*	Candidate	No. The US 281 project area falls within the San Antonio River basin and is out of the range for this species, thus the US 281 Corridor Project would have ***no impact*** on this species.

Table 2-1: Summary of Threatened and Endangered Species and Potential for Effect/Impact by the US 281 Corridor Project

Common Name	Scientific Name	Status	Potential Occurrence Within the Project Area and Effect/Impact Determination
Peck's Cave amphipod	*Stygobromus pecki*	Endangered	No. This species is found only in the region of Comal Springs and Hueco Springs in Comal County, thus the US 281 project area is outside the known range of this species. Although the US 281 Corridor Project would have no direct effect on this species, the potential for indirect effects to species dependent on Comal Springs was evaluated. Given the distance of the US 281 Corridor Project from Comal Springs (approximately 20 miles), the fact that this project is a widening of an existing roadway, and the pollutant removal which would be achieved with TCEQ approved storm water best management practices (BMPs), indirect effects resulting from the US 281 Corridor Project on Comal Springs are not reasonably certain to occur in the future. Therefore, this project would have ***no effect*** on this species.
Braken Bat Cave meshweaver	*Cicurina venii*	Endangered	No. The US 281 project area is located entirely within the Stone Oak KFR. While appropriate habitat may be present, this species is known only from the Culebra Anticline KFR, thus the US 281 project area is more than 20 miles east of the currently understood distribution of this species. Therefore, the US 281 Corridor Project is expected to have ***no effect*** on this species.
Cokendolpher Cave harvestman	*Texella cokendolpheri*	Endangered	No. The currently understood range of this species begins seven miles to the south in an outcrop of the Austin Chalk within the Alamo Heights KFR. The US 281 project area is entirely within the Stone Oak KFR and there are no caves formed in the Austin Chalk occurring within the project area; therefore this US 281 Corridor Project would have ***no effect*** on this species.

Table 2-1: Summary of Threatened and Endangered Species and Potential for Effect/Impact by the US 281 Corridor Project

Common Name	Scientific Name	Status	Potential Occurrence Within the Project Area and Effect/Impact Determination
Government Canyon Bat Cave meshweaver	*Cicurina vespera*	Endangered	No. The US 281 project area is located entirely within the Stone Oak KFR. While appropriate habitat may be present, this species is known only from the Government Canyon KFR, thus the US 281 project area is approximately 18 miles east of the currently understood distribution of this species. Therefore, the US 281 Corridor Project is expected to have ***no effect*** on this species.
Government Canyon Bat Cave spider	*Neoleptoneta microps*	Endangered	No. The US 281 project area is located entirely within the Stone Oak KFR. While appropriate habitat may be present, this species is known only from the Government Canyon KFR, thus the US 281 project area is approximately 18 miles east of the currently understood distribution of this species. Therefore, the US 281 Corridor Project is expected to have ***no effect*** on this species.
Madla Cave meshweaver	*Cicurina madla*	Endangered	Yes. Although the currently understood range of this species lies seven miles to the west, it occurs within the Stone Oak KFR, so its potential presence in the project area cannot be entirely discounted. Therefore, the US 281 Corridor Project ***may affect, and is likely to adversely affect,*** this species.
Robber Baron Cave meshweaver	*Cicurina baronia*	Endangered	No. The currently understood range of this species according to USFWS begins seven miles to the south in an outcrop of the Austin Chalk within the Alamo Heights KFR. The US 281 project area is entirely within the Stone Oak KFR and there are no caves formed in the Austin Chalk occurring within the project area; therefore this US 281 Corridor Project would have ***no effect*** on this species.

Table 2-1: Summary of Threatened and Endangered Species and Potential for Effect/Impact by the US 281 Corridor Project

Common Name	Scientific Name	Status	Potential Occurrence Within the Project Area and Effect/Impact Determination
Comal Springs dryopid beetle	*Stygoparnus comalensis*	Endangered	No. This species is found only in the region of Comal Springs and Hueco Springs in Comal County, thus the US 281 project area is outside the known range of this species. Although the US 281 Corridor Project would have no direct effect on this species, the potential for indirect effects to species dependent on Comal Springs was evaluated. Given the distance of the US 281 Corridor Project from Comal Springs (approximately 20 miles), the fact that this project is a widening of an existing roadway, and the pollutant removal which would be achieved with TCEQ approved storm water BMPs, indirect effects resulting from the US 281 Corridor Project on Comal Springs are not reasonably certain to occur in the future. Therefore, this project would have ***no effect*** on this species.
Comal Springs riffle beetle	*Heterelmis comalensis*	Endangered	No. This species is found only in the region of Comal Springs and Hueco Springs in Comal County, thus the US 281 project area is outside the known range of this species. Although the US 281 Corridor Project would have no direct effect on this species, the potential for indirect effects to species dependent on Comal Springs was evaluated. Given the distance of the US 281 Corridor Project from Comal Springs (approximately 20 miles), the fact that this project is a widening of an existing roadway, and the pollutant removal which would be achieved with TCEQ approved storm water BMPs, indirect effects resulting from the US 281 Corridor Project on Comal Springs are not reasonably certain to occur in the future. Therefore, this project would have ***no effect*** on this species.

Table 2-1: Summary of Threatened and Endangered Species and Potential for Effect/Impact by the US 281 Corridor Project

Common Name	Scientific Name	Status	Potential Occurrence Within the Project Area and Effect/Impact Determination
Ground beetle	*. exilis*	Endangered	Yes. This species occurs in CHU 12, adjacent to the project corridor. Although *Rhadine* species are not known to occur in voids intersected by downcutting of grade, its potential presence in those voids cannot be entirely discounted. Therefore the US 281 Corridor Project ***may affect, and is likely to adversely affect,*** this species.
Ground beetle	*Rhadine infernalis*	Endangered	Yes. Although the currently understood range of this species lies 1.7 miles to the west, it occurs within the Stone Oak KFR, so its potential presence in the project area cannot be entirely discounted. The US 281 Corridor Project ***may affect, and is likely to adversely affect,*** this species.
Helotes mold beetle	*Batrisodes venyivi*	Endangered	No. The US 281 project area is outside located entirely within the Stone Oak KFR. This species is known only from the Government Canyon and Helotes KFRs, thus the project area is outside of the known range of this species. Therefore, the US 281 Corridor Project would have ***no effect*** on this species.
Fountain darter	*Etheostoma fonticola*	Endangered	No. This species is found only in the region of Comal Springs and Hueco Springs in Comal County, thus the US 281 project area is outside the known range of this species. Although the US 281 Corridor Project would have no direct effect on this species, the potential for indirect effects to species dependent on Comal Springs was evaluated. Given the distance of the US 281 Corridor Project from Comal Springs (approximately 20 miles), the fact that this project is a widening of an existing roadway, and the pollutant removal which would be achieved with TCEQ approved storm water BMPs, indirect effects resulting from the US 281 Corridor Project on Comal Springs are not reasonably certain to occur in the future. Therefore, this project would have ***no effect*** on this species.

Table 2-1: Summary of Threatened and Endangered Species and Potential for Effect/Impact by the US 281 Corridor Project

Common Name	Scientific Name	Status	Potential Occurrence Within the Project Area and Effect/Impact Determination
San Marcos salamander	*Eurycea nana*	Threatened	No. The US 281 project area is outside the known range of this species, thus the US 281 Corridor Project would have ***no effect*** on this species.
Texas blind salamander	*Eurycea rathbuni*	Endangered	No. This species is found only in the region of Comal Springs and Hueco Springs in Comal County, thus the US 281 project area is outside the known range of this species. Although the US 281 Corridor Project would have no direct effect on this species, the potential for indirect effects to species dependent on Comal Springs was evaluated. Given the distance of the US 281 Corridor Project from Comal Springs (approximately 20 miles), the fact that this project is a widening of an existing roadway, and the pollutant removal which would be achieved with TCEQ approved storm water BMPs, indirect effects resulting from the US 281 Corridor Project on Comal Springs are not reasonably certain to occur in the future. Therefore, this project would have ***no effect*** on this species.
Interior least tern	*Sterna antillarum athalassos*	Endangered	No. Sand and gravel bars within braided streams and rivers, as well as suitable man-made structures, do not exist within the US 281 project area. Therefore, the US 281 Corridor Project would have ***no effect*** on this species.
Black-capped vireo	*Vireo atricapilla*	Endangered	No. The appropriate shrub and tree layer with open, grassy spaces required by the Black-capped vireo does not exist within the US 281 project area, thus the US 281 Corridor Project would have ***no effect*** on this species.
Golden-cheeked warbler	*Setophaga chrysoparia*	Endangered	Yes. Potential habitat for this species exists within the US 281 project area; however, this species was not observed during the 2009, 2010, and 2014 presence/absence surveys. However, there are some small areas of potential habitat that will be altered and have not been surveyed. Therefore, the US 281 Corridor Project ***may affect, but is not likely to adversely affect,*** this species.

Table 2-1: Summary of Threatened and Endangered Species and Potential for Effect/Impact by the US 281 Corridor Project

Common Name	Scientific Name	Status	Potential Occurrence Within the Project Area and Effect/Impact Determination
Sprague's pipit	*Anthus spragueii*	Candidate	No. Native prairie/grassland does not occur in the vicinity of the proposed project; therefore, the project would have ***no impact*** on this species.
Whooping crane	*Grus americana*	Endangered	No. Potential migrant; use of the US 281 project area would not be expected due to lack of habitat. The US 281 Corridor Project would have ***no effect*** on this species.

Source: USFWS 2014b.

The following sections provide the life history, range and distribution, and/or habitat requirements of each species which may be impacted by the proposed project.

Migratory Birds

In addition to those species listed, to ensure that impacts to other migratory bird species are avoided, typical measures would be in place to comply with the Migratory Bird Treaty Act. The following conservation measures are proposed: vegetation clearing would take place outside nesting season to the extent practicable, and if possible, in the year prior to construction and the contractor would be required to remain vigilant for the presence of early nesting species if vegetation clearing occurs in mid-winter. In the event that migratory birds are encountered on-site during construction, every effort would be made to avoid harm to protected birds, active nests, eggs, and/or young. The contractor would remove any old migratory bird nests between September 1 and February 28 from any structure where work would be done. In addition, the contractor would be prepared to prevent migratory birds from building nests between March 1 and August 31.

Plants

Bracted twistflower (Streptanthus bracteata)

Streptanthus bracteatus is a rare annual wildflower endemic to south-central Texas. This species is associated with oak-juniper woodlands and openings on slopes and in canyon bottoms with shallow, well drained gravelly clay and clay loam soils over limestone. Fall and winter rainfalls stimulate seed germination and plants flower in the spring, displaying showy, lavender-purple flowers (NatureServe 2014). Given uncertainty associated with its presence or absence, there is a potential that *S. bracteatus* occurs within the US 281 Corridor and may be impacted by the proposed project.

Karst Invertebrates

Due to similarities in habitat, the federally endangered karst invertebrate species, including both arachnids and insects are combined into one discussion.

Madla Cave meshweaver (Cicurina madla)

Cicurina madla is a pale, eyeless, troglobitic spider first collected on October 4, 1963, by J. Reddell and D. McKenzie (Reddell 1993a) and described by Gertsch (1992). This species inhabits caves and mesocavernous voids, including those with sparse organic input. *C. madla* has been confirmed in 22 Bexar County caves in the Government Canyon, Helotes, and Stone Oak KFRs, and may occur in two additional caves in the Helotes and Stone Oak KFRs (USFWS 2011b). The eastern limit of the currently understood range for this species is located seven miles west of the US 281 project area in Camp Bullis within the Stone Oak KFR, but there are no known localities within the US 281 project area, or outside of Camp Bullis within the Stone Oak KFR. Although appropriate habitat for this species is present, this species was not encountered during the 2010 presence-absence surveys and none are historically known to occur in the US 281 project area. Other, non-listed *Cicurina* species occur in the vicinity of project area, including *C. bullis*, C. *platypus*, and C. *puentecilla*.

Ground Beetle (Rhadine exilis)

Rhadine exilis is a small, slender-bodied, essentially eyeless, troglobitic ground beetle. It inhabits caves that have natural entrances; it is not known to been to have been encountered in accidentally discovered voids during construction activities. It was first collected in 1959 and described as *Agonum exile* but later assigned to the genus *Rhadine.* (Barr 1974). The species is currently confirmed in 51 caves in the Government Canyon Helotes, UTSA, and Stone Oak KFRs and may occur in two additional caves in the UTSA KFR in Bexar County (USFWS 2011b). The currently understood range of this species overlaps with the US 281 project area, including CHU 12, which was created for *R. exilis*; however, there are no known localities within the US 281 project area and presence-absence surveys performed in 2010 within potential habitat did not result in any observations or collections of this species.

Ground Beetle (Rhadine infernalis)

Rhadine infernalis is a small, slender-bodied, essentially eyeless, troglobitic ground beetle. It inhabits caves that have natural entrances; it is not known to been to have been encountered in accidentally discovered voids during construction activities. It was first collected in 1959 and initially described by Barr and Lawrence (1960) as *Agonum infernale*, but later assigned to the genus *Rhadine* (Barr 1974). USFWS (2011b) documents this species as occurring in 39 caves in the Culebra Anticline, Helotes, UTSA, and Stone Oak KFRs located in Bexar County; recent surveys have encountered this species in two additional caves within the Culebra anticline KFR. Recently collected specimens were taxonomically verified by James Reddell (2014). The closest confirmed location of this species is in Genesis Cave, approximately 1.7 miles west of the US 281 project corridor, west of Stone Oak Parkway and north of Loop 1604, and there are no known localities within the US 281 karst survey area. Presence-absence surveys performed in 2010 within potential habitat did not result in any observations or collections of this species.

Birds

Golden-cheeked Warbler (Setophaga chrysoparia)

The state and federally endangered Golden-cheeked Warbler (GCWA) is a small insectivorous neotropical and migratory songbird. Males have a black back, throat, upper breast, and crown, white belly, black-streaked sides, white wing bars, and a black line through the eye with large yellow patches both above and below the eye. Females and immature individuals are duller, with olive upperparts with dark streaks and a yellowish or white chin (NatureServe 2009). This songbird nests only in the mixed juniper-oak woodlands of Central Texas. This species, which winters in southern Mexico and the Central American countries of Guatemala, Honduras, and Nicaragua, is the only Texas species whose breeding range is entirely confined to the state's boundaries. The known breeding range of the GCWA includes 37 Texas counties on the Lampasas Cut Plain, Edwards Plateau, and Llano Uplift regions of the state (USFWS 1992). They breed in woodlands characterized by a mix of Ashe juniper and various deciduous trees including Texas oak, plateau live oak, cedar elm, Texas persimmon, hackberry (*Celtis* spp.), evergreen sumac (*Rhus virens*), Texas ash (*Fraxinus texensis*), redbud (*Cercis canadensis*), and escarpment black cherry (*Prunus serotina*) (USFWS 1992). Ashe juniper is often the dominant woody plant and occurs at all sites occupied by the bird. Females construct nests from Ashe juniper bark, which exfoliates in the form of strips, especially in more mature trees (Pulich 1976). Potential habitat for this species exists within the US 281 project area, however, this species was not observed during the 2009, 2010, and 2014 presence/absence surveys.

2.3 STATUS OF LISTED SPECIES WITHIN THE ACTION AREA

Based upon analysis of known range distributions, existing habitat and/or presence/absence surveys, there are no species known at this time to be directly affected by the project; however, those with a chance of being indirectly affected are addressed below in more detail. These include three terrestrial karst invertebrates and one avian species.

2.3.1 Status of Potentially Affected Karst Invertebrates

Three listed karst invertebrate species have the potential to occur within the action area: *R. exilis*, *R. infernalis*, and *C. madla*. These species have a recovery priority number of 2C because they face a high degree of threat with a high potential for recovery, and there may be conflict between species recovery and economic development (USFWS 2011a).

Description

Cicurina madla is a small, eyeless spider and *R. exilis* and *R. infernalis* are small, essentially eyeless ground beetles. All of the listed invertebrates are obligate cave species known as troglobites; compared to surface species, troglobitic species generally have smaller geographic ranges and specific limitations to a particular geographic area, making them biogeographically distinct (Porter 2007, Christman et al. 2005) and particularly susceptible to extinction (Elliott and Reddell 1989, Culver et al. 2000).

Habitat and Life History

Habitat for karst invertebrates occurs in limestone caves and mesocaverns (i.e. humanly impassable voids within the bedrock). Within this environment, these animals are dependent on high humidity, stable temperatures, and external energy sources. Nutrient sources can include large particle sizes that enter through obvious entrances, such as leaf litter, particulate organic carbon, animal droppings, and animal carcasses (USFWS 2011a). In entranceless caves, or voids encountered during construction such as those encountered at this project site, nutrients probably enter via diffuse flow of particulate organic carbon and dissolved organic carbon from soils and dripwater. The carbon in the dissolved organic matter in soil is immobilized in microbial biofilms. Primary consumers, such as springtails, mites, and snails, feed on these biofilms and are then prey for spiders and larger arthropods (Simon et al. 2003). Simon et al. (2007) modeled carbon flow based on measurements at two caves and showed that while humanly accessible cave entrances contributed the majority of dissolved organic carbon in systems with both pathways (localized and diffuse), soils and epikarst contributed significant amounts of carbon as well. This study showed the importance of water that percolates through cave drips, very small cracks, root paths, bedding planes, or other very small voids. In the case of these voids that are located within 33 feet of the original land surface, tiny arthropods such as springtails may also feed in the near-to-surface plant-rich soil zone and travel through these tiny tunnels, ultimately becoming a food source for spiders and other predators. General habitat characteristics for the federally listed Bexar County karst invertebrates are described below.

Humidity and Temperature

Troglobites require stable temperatures and high humidity approaching near saturation (Barr 1968, Culver 1982, Elliott and Reddell 1989). Generally, areas within caves that have low humidity are almost entirely devoid of cave fauna (Elliott and Reddell 1989). To sustain humid conditions, it is necessary to protect both the surface and subsurface drainage basins. This serves to maintain the supply of moisture to the cave and connected karst areas and also to insulate the karst system from extreme temperature fluctuations (USFWS 2011a).

Drainage Basins

Water enters the karst ecosystem through both groundwater and surface drainage basins. Water is rapidly transported through cave openings, fractures, and solutionally enlarged bedding planes with little or no purification. Consequently, karst systems are highly sensitive to pollution from contaminated water traveling through the surface and subsurface drainage basins. The potential for pollutants, such as pesticides, fertilizers, and leakage from sewer lines, may be heightened in some karst areas relative to others based on local geologic features (USFWS 1994). Due to these factors, protecting caves' drainage basins is a major consideration (USFWS 2011a).

Surface Communities

Due to the absence of sunlight, and therefore primary productivity, cave organisms rely almost entirely upon surface plant and animal communities for nutrient input. Surface plant communities provide nutrients through leaf litter that enters caves or karst voids and from root masses that may grow directly into caves (Howarth 1983). Surface plant communities also serve as a buffer against changes to moisture and temperature regimes within the karst ecosystem (Biological Advisory Team 1990, Veni 1988). Surface animals provide food for trogloxenes (i.e., animals that spend only a portion of their life cycle in the subterranean environment) such as cave crickets, bats, toads, and frogs (USFWS 2011a). Primary sources of nutrients in the karst ecosystem are leaf litter, cave crickets, small mammals, and other animals that defecate or die in the cave (USFWS 2012).

Mesocavernous Habitat

The use of interstitial spaces or mesocaverns by troglobites may play an important part in these species' viability. These areas are defined as small, humanly inaccessible, solutionally enlarged voids that provide potential habitat for cave-dwelling species in the areas between caves (George Veni & Associates 1994). Troglobites most likely use these areas the majority of the time, since humidity and temperature levels remain more stable than in larger caves (Howarth 1983). Use of interstitial spaces by troglobites has been observed in Japan, Hawaii, and Texas (Howarth 1983, Sprouse and Krejca 2009), and it is common to visit a cave several times before detecting the presence of a karst species. Krejca and Weckerly (2007) assessed the detection probabilities of three karst invertebrates, including *R. exilis*, during karst faunal surveys. The results of their study suggest that ten to 22 visits may be required in order to confirm presence. For example, while surveying one feature associated with the State Highway (SH) 151 underpass of Loop 1604, the eyeless *Cicurina* sp. was not found until the 12th survey, indicating that in this case 12 visits was enough to detect the species, but 11 was not (TxDOT 2013b). Furthermore, central Texas endangered karst invertebrates have been found in caves that immediately prior to sampling had no humanly accessible entrances (Horizon Environmental Services 1991, George Veni & Associates 2003). In order to support karst invertebrates, mesocavernous spaces should be a minimum width of 0.2 to 0.4 inches, which also corresponds to the threshold of turbulent groundwater flow that could potentially carry nutrients to karst species (Howarth 1983, George Veni & Associates 1994).

Physical factors in caves that affect the life history of karst invertebrate species include absence of sunlight, low nutrient flow (due to lack of primary production), and a stable environment with uniform temperature and humidity. These parameters favor the evolution of troglomorphic characteristics including reduction or loss of eyes, reduced pigmentation, and attenuated limbs and olfactory organs (USFWS 2011a). Additionally, nearly all cave-adapted organisms exhibit the following characteristics: delayed reproduction, larger eggs, relatively small number of total eggs produced, and increased longevity (Culver 1982). Although the average life span of any of the listed troglobitic invertebrates is currently unknown (USFWS 2011a), it is likely to be multiple years for some species, such as the *Cicurina* spp. spiders (Bennett 1985, Cokendolpher 2004).

Population dynamics

These species are known from karst habitat in Bexar County only, and population estimates are unknown due to a lack of rangewide survey techniques, their cryptic behavior, and the nature of their confined, subterranean habitat areas (USFWS 2011a).

Status and distribution

The northern portion of Bexar County is located on the Edwards Plateau, a broad and flat expanse of Cretaceous carbonate rock. The principal cave-containing rock units of the Edwards Plateau are the upper Glen Rose, Edwards Limestone, Austin Chalk, and Pecan Gap Chalk formations. One-third of the cavernous rock exposed at the surface in Bexar County is of the Edwards Limestone formation, making it the most cavernous unit in the county (Veni 1988, George Veni & Associates 1994).

Based on the geologic restrictions on the distribution of cave fauna and the locations of known caves, George Veni & Associates (1994) delineated five karst zones that reflect the relative likelihood of finding any of the Bexar County listed troglobites (and other rare or endemic karst species) (**Figure 2-2**). These five zones are defined as:

Zone 1: Areas known to contain one or more of the listed karst invertebrates.

Zone 2: Areas having a high probability of suitable habitat for the listed karst invertebrates.

Zone 3: Areas that probably do not contain listed karst invertebrates.

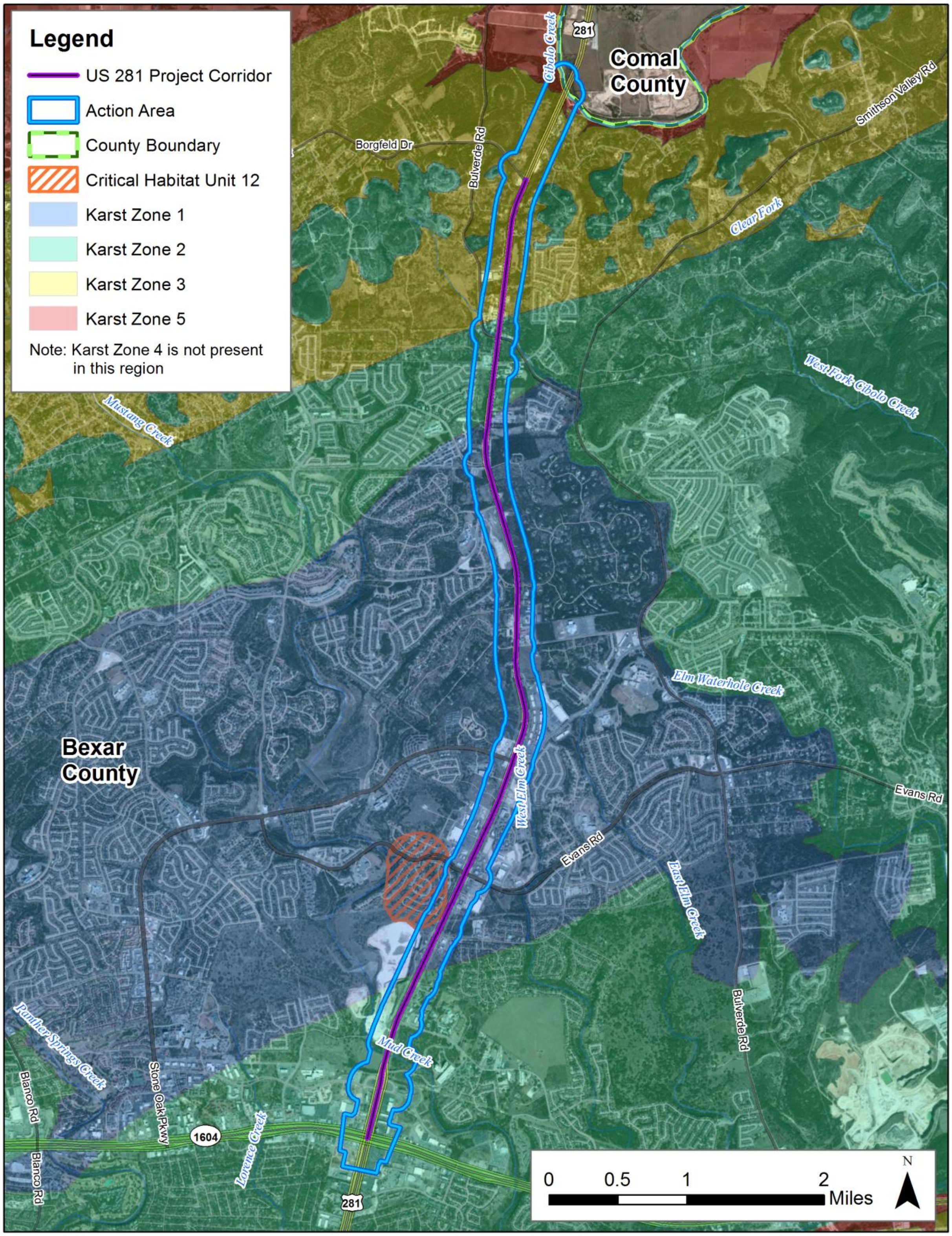
Zone 4: Areas that require further research, but are generally equivalent to Zone 3, although they may include sections that could be classified as Zone 2 or Zone 5.

Zone 5: Areas that do not contain listed karst invertebrates.

Under contract with the USFWS, George Veni & Associates (2003) re-evaluated and, where applicable, redrew the boundaries of each karst zone originally delineated in George Veni & Associates (1994). Revisions were based on current geologic mapping, further studies of cave and karst development, and the most current information available on the distribution of listed and non-listed troglobites (George Veni & Associates 2003). These zones are depicted in the US 281 project area, which includes the existing and proposed ROW and an area extending 500 foot outward from the existing and proposed ROW to capture disturbance from construction activities that have the potential to extend beyond the project footprint (**Figure 2-2**). The acreage of each karst zone within the project area and the proposed project are listed in **Table 2-2**.

Thirty critical habitat units (CHUs) were designated for the nine federally listed Bexar County karst invertebrates via issuance of a final rule on February 14, 2012 (USFWS 2012). One of these units, CHU 12, occurs adjacent to the project corridor and within the action area. This unit is described in detail in **Section 2.5**.

Figure 2-2: Karst zones within the US 281 project area



Source: George Veni & Associates (2003, 1994); US 281 EIS Team 2011 (July).

Table 2-2: Karst Zone Acreage within the ROW for the proposed project.

Karst Zone 1 acres	Karst Zone 2 acres	Karst Zone 3 acres	Karst Zone 4 acres	Karst Zone 5 acres
225	134	85	0	3

Source: USFWS 2003; US 281 EIS Team 2011 (July)

George Veni & Associates (1994) also established six geographic areas (Stone Oak, UTSA, Helotes, Government Canyon, Culebra Anticline, and Alamo Heights) called Karst Faunal Regions (KFRs) within the Bexar County Karst Zones (**Figure 2-3**). These divisions were defined by hydrogeologic barriers or other restrictions to the migration of troglobitic species over evolutionary time (Veni 2009). These six KFRs were used in the USFWS final rule designating critical habitat to define the ranges of the federally listed karst invertebrates. The US 281 project area primarily contained within the Stone Oak KFR, which is known to contain the following federally listed karst invertebrate species: *C. madla, R. exilis,* and *R. infernalis*.

As of December 2013, 605 caves were known to occur in Bexar County, some of which have been biologically surveyed for listed karst invertebrates (George Veni pers. comm. 2013). At least 97 of these caves were sealed or destroyed before they could be biologically surveyed (George Veni & Associates 2003). Many of the remaining caves in the county have not been adequately surveyed and could be found to contain one or more of the listed species. A total of 93 caves have been confirmed to contain listed karst invertebrates (USFWS 2011a); however, because of the lack of complete sampling, it should be noted that this list is not likely to represent the real range for these species. The current status of species' populations in most of these caves is unknown. Also, many of these sites are lacking the recommended protection of a minimum of 40 acres of contiguous, unfragmented, undisturbed land to maintain both the native plant and animal communities around the feature that will help protect the integrity of the cave community (USFWS 2011a).

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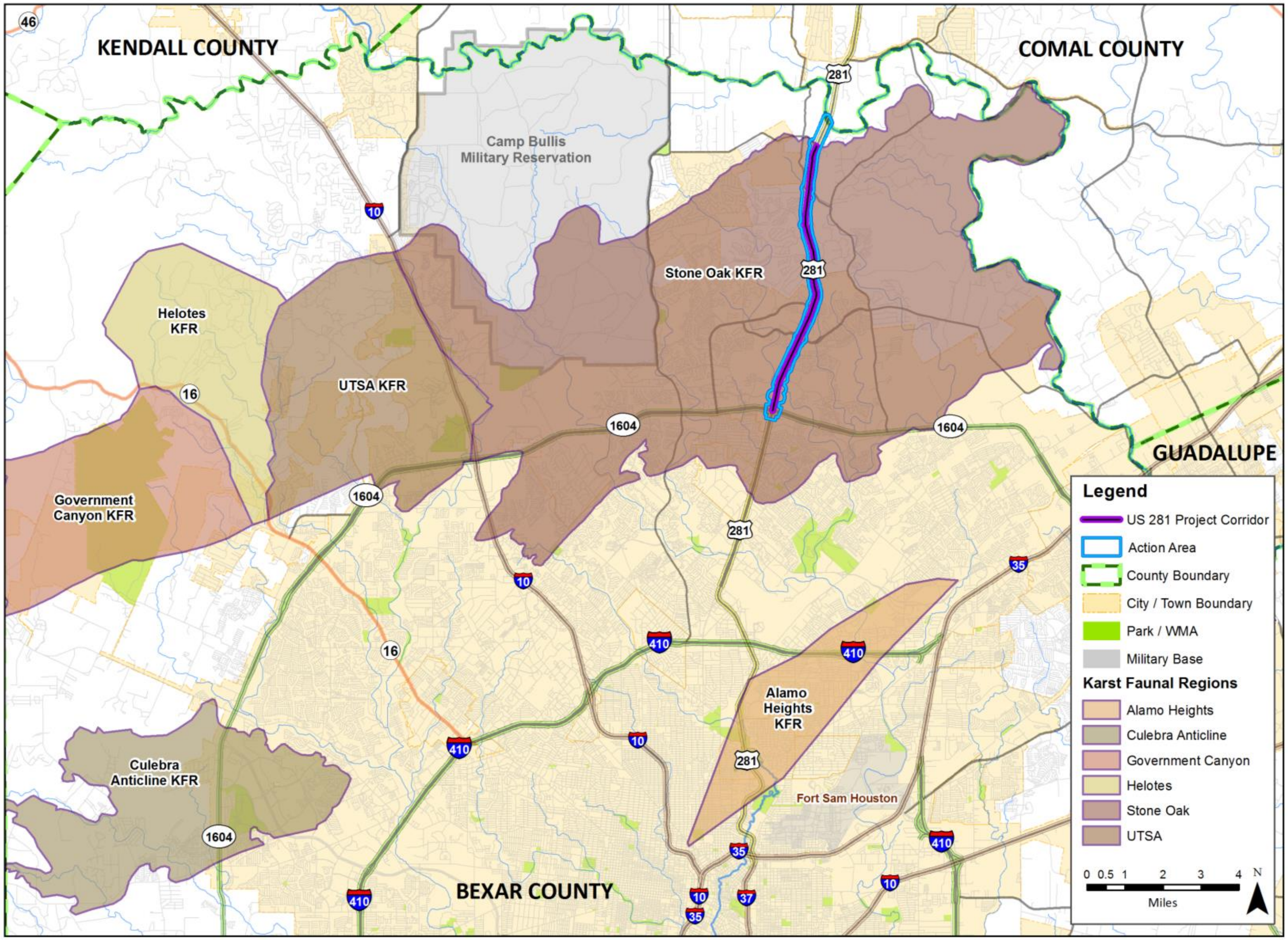
Figure 2-3: Karst Fauna Regions within Bexar County



Source: George Veni & Associates (2003, 1994); US 281 EIS Team 2014 (December).

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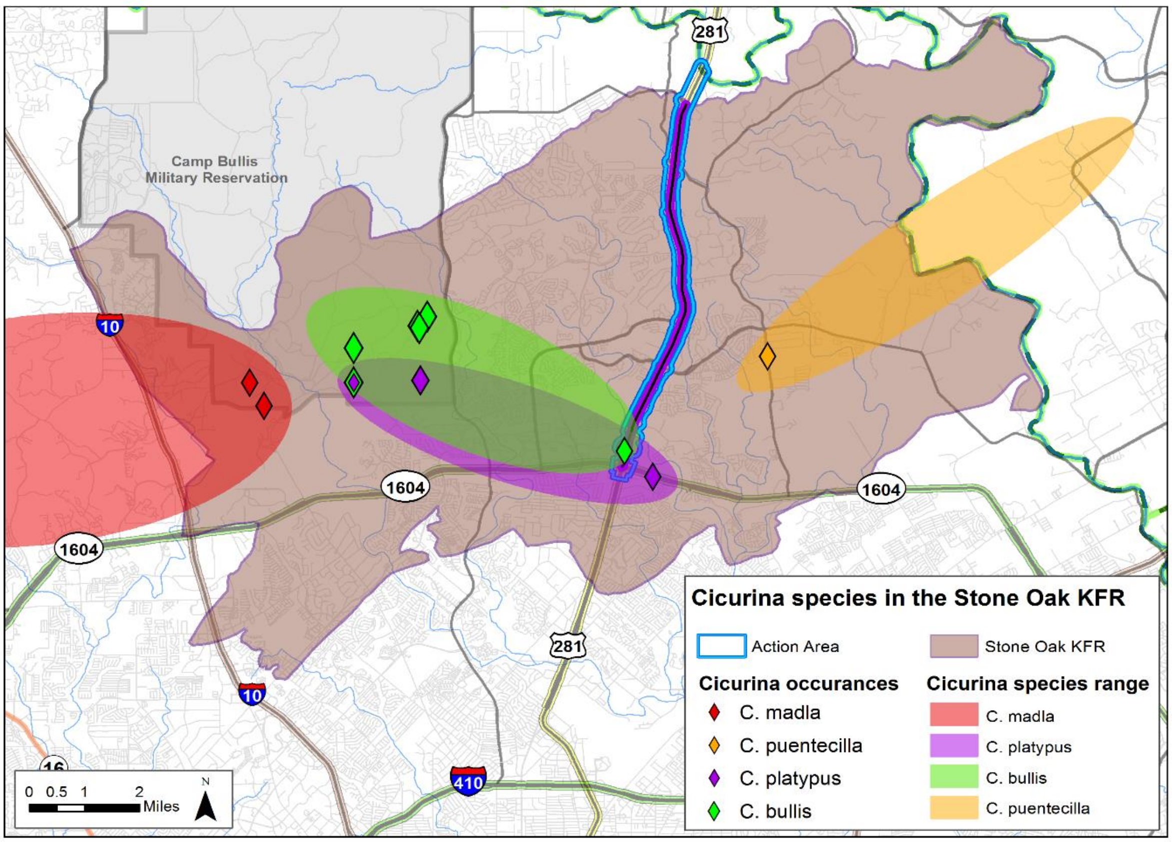
Cicurina madla has been confirmed in 22 Bexar County caves in the government Canyon, Helotes, and Stone Oak KFRs, and may occur in additional caves in the Helotes and Stone Oak KFRs (USFWS 2011b). The eastern limit of the currently understood range for this species is located seven miles west of the US 281 project area in Camp Bullis within the Stone Oak KFR, and there are no known localities within the US 281 project area, or outside of Camp Bullis within the Stone Oak KFR (**Figure 2-4**). Presence-absence surveys performed in 2010 within potential habitat in the US 281 project area did not result in any observations or collections of this species; however, knowledge of the distribution of eyeless *Cicurina* species in Bexar County is constantly changing, as specimens are collected from additional sites. This can result in range extensions, some of which that may leap over or around the ranges of other species in the genus. The taxonomy of *Cicurina* populations is expected to change with further genetic analysis. When species of the genus were first described, they were done so solely on a morphological basis, which only considers adult specimens. TxDOT is currently conducting genetic research on *Cicurina* species in Bexar and surrounding counties with the goal of developing molecular techniques to discriminate between species reliably.

Figure 2-4: Currently Known Range of *Cicurina madla* and other *Cicurina* species

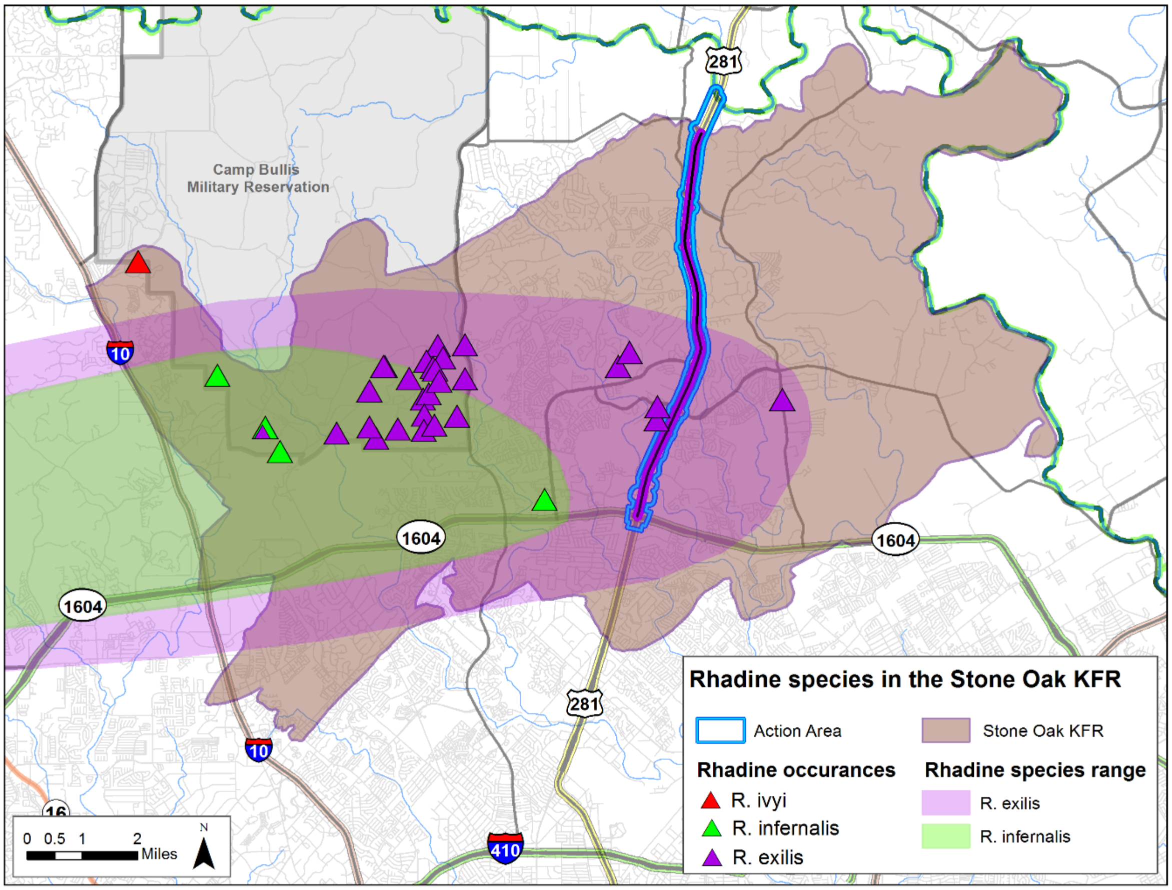


Source: Cokendolpher 2004; TSS 2010, US 281 EIS Team 2014 (December).

Rhadine exilis is currently confirmed in 51 caves in the Government Canyon, Helotes, UTSA, and Stone Oak KFRs and may occur in two additional caves in the UTSA KFR in Bexar County (USFWS 2011b). The currently understood range of this species overlaps with the US 281 project area, including CHU 12, which was created for *R. exilis*; however, there are no known localities within the US 281 project area and presence-absence surveys performed in 2010 within potential habitat did not result in any observations or collections of this species (**Figure 2-5**).

Rhadine infernalis is known from 39 caves in the Culebra Anticline, Helotes, UTSA, and Stone Oak KFRs located in Bexar County (USFWS 2011b). The closest confirmed location of this species is in Genesis Cave, approximately 1.7 miles west of the US 281 project corridor, west of Stone Oak Parkway and north of Loop 1604, and there are no known localities within the US 281 karst survey area (**Figure 2-5**). Presence-absence surveys performed in 2010 within potential habitat did not result in any observations or collections of this species.

Figure 2-5: Range of *Rhadine exilis* and *Rhadine infernalis*



Source: Reddell 2004: TSS 2010, US 281 EIS Team 2014 (December).

Threats

The primary threat to karst invertebrate species is habitat loss due to increased human expansion and urbanization throughout the karst terrain in Bexar County. Threats associated with increased urbanization include filling in and collapsing of caves, alteration of drainage patterns, alteration of surface plant and animal communities, contamination, and vandalism (USFWS 2011a, USFWS 2012).

In addition, the continued spread of non-native, invasive species, such as the red-imported fire ant (*Solenopsis invicta*), poses a serious threat to karst invertebrates through direct predation and competition with native species (Taylor et. al 2004, USFWS 2011a). This is a particularly important issue for listed invertebrates in central Texas because many of the caves in this region are shallow and provide refuge to red-imported fire ants during temperature extremes. Red-imported fire ants have also been directly observed attacking and carrying off cave crickets, a species that serves an integral role in the karst ecosystem (Elliott 2000). This threat may be intensified by edge effects associated with the soil disturbance and disruption to native communities that come with urbanization (Reddell 1993b).

Due to low known population densities, the rarity of encountering some species (Krejca and Weckerly 2007), and the potential for numerous confounding variables, potential impacts affecting karst invertebrates are inherently difficult to detect. Population responses may not be immediate and/or detectible (Howarth 1983, Miller and Reddell 2005).

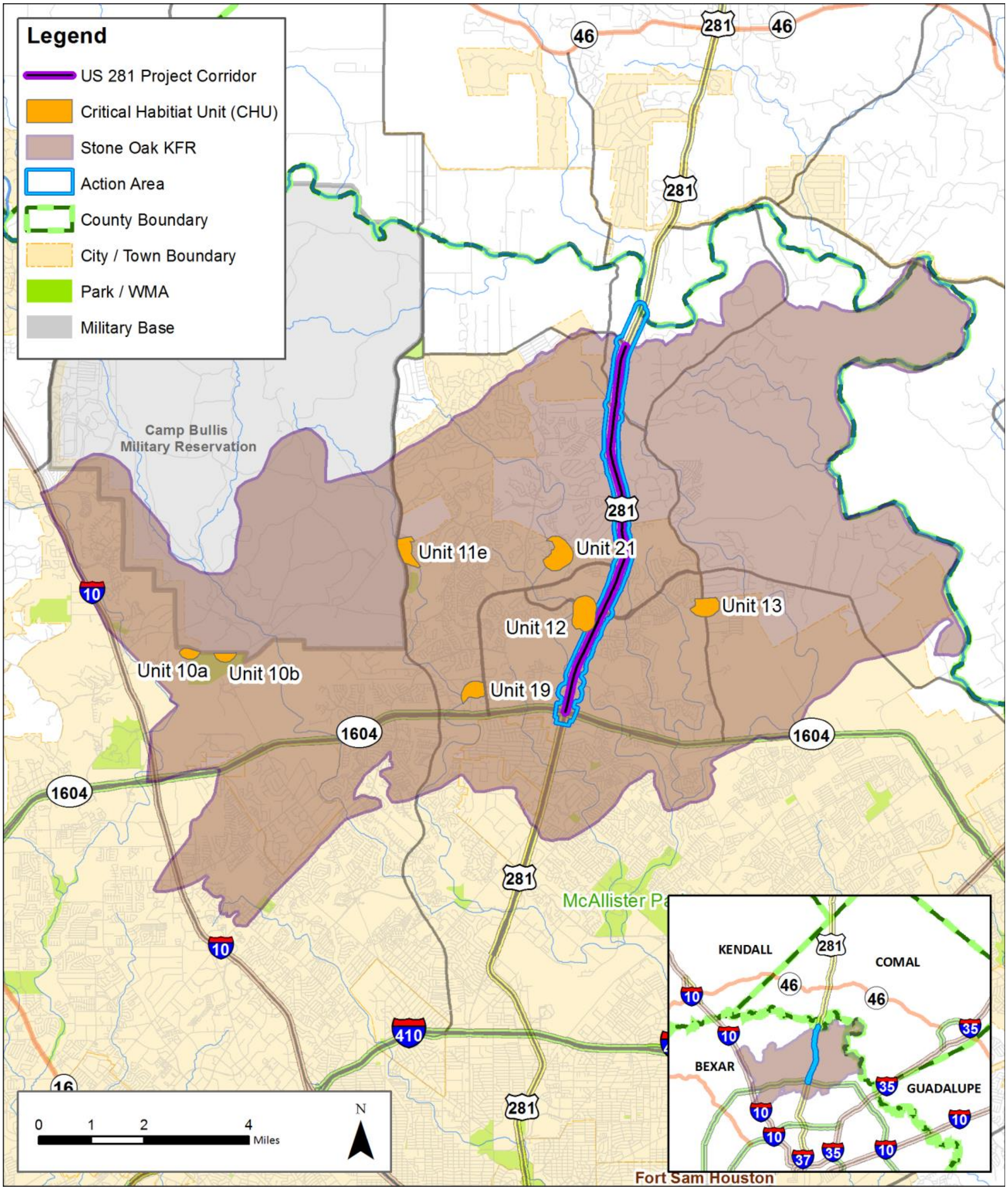
Critical Habitat

Approximately 4,216 acres of critical habitat in 30 CHUs were designated for all nine federally listed Bexar County karst invertebrates in 2012 (USFWS 2012). Several CHUs for karst invertebrates occur near the project corridor (**Figure 2-6**). These include CHUs 10a, 10b, 11e, 12, 13, 19, and 21. Except for CHU 12, no CHUs are present in either the proposed ROW or the action area.

CHU 12 is a 166 acre unit containing Hairy Tooth and Ragin' Cajun Caves, both known to contain *R. exilis.* This CHU is located on the west side of the US 281 project corridor near Evans Road (**Figure 2-7** and **Figure 2-8**), and is bounded by US 281 to the east, a quarry on the south, and a school and residential development to the west. CHU 12 was delineated by drawing 100-acre circles around the two caves and joining the edges of the two overlapping circles, then subtracting out a quarried-away segment at the south end. CHU 12 is characterized by low-quality habitat due to urbanization within its boundaries and quarrying adjacent to the south of its boundaries. The unit extends into the ROW for a maximum width of 11 feet along 180 feet of the eastern of the CHU, forming a shallow triangle totaling 0.023 acres within the ROW. The 0.023 acres of CHU 12 within the existing US 281 ROW consists of sparse, unmaintained woody vegetation and grasses on limestone bedrock, separated from the remainder of the CHU by a concrete block fence (**Figure 2-9**).

Areas of undisturbed, native vegetation and associated surface wildlife, both of which are considered to be primary constituent elements (PCEs) for karst species habitat, are sparse within CHU 12 and absent within the 0.023 acres within the ROW. Most of CHU 12 consists of single family homes in the Big Spring subdivision on small lots, where little remains of pre-existing natural vegetative and surface hydrologic patterns. In addition to the limitations associated with existing residential and industrial development, CHU 12 exhibits other habitat limitations. Hairy Tooth Cave is surrounded by streets on three sides, and by a residence on the fourth (**Figure 2-10**). It is situated on an undeveloped lot, approximately 0.45 acres in size, about half of which is mowed and half is wooded. Ragin' Cajun Cave is bounded by streets on two sides and by four residences on the other two. It is situated on a fenced lot of 0.6 acres, and consists of natural vegetation. Significant disturbance of the subsurface within and around these caves and CHU 12 due to the installation of water, wastewater, stormwater and other subsurface utilities has already occurred. Impacts to mesocavernous habitat (another PCE) likely occurred during subsurface utility placement; however, the depth of these impacts is unknown. Previous subsurface impacts extend outward from the CHU in the existing ROW where stormwater conveyances were placed across the ROW during the original construction of US 281. The depth of existing subsurface impacts in the ROW is 13 feet below grade.

82 **Figure 2-6: Critical Habitat Units within Bexar County and the US 281 action area.**

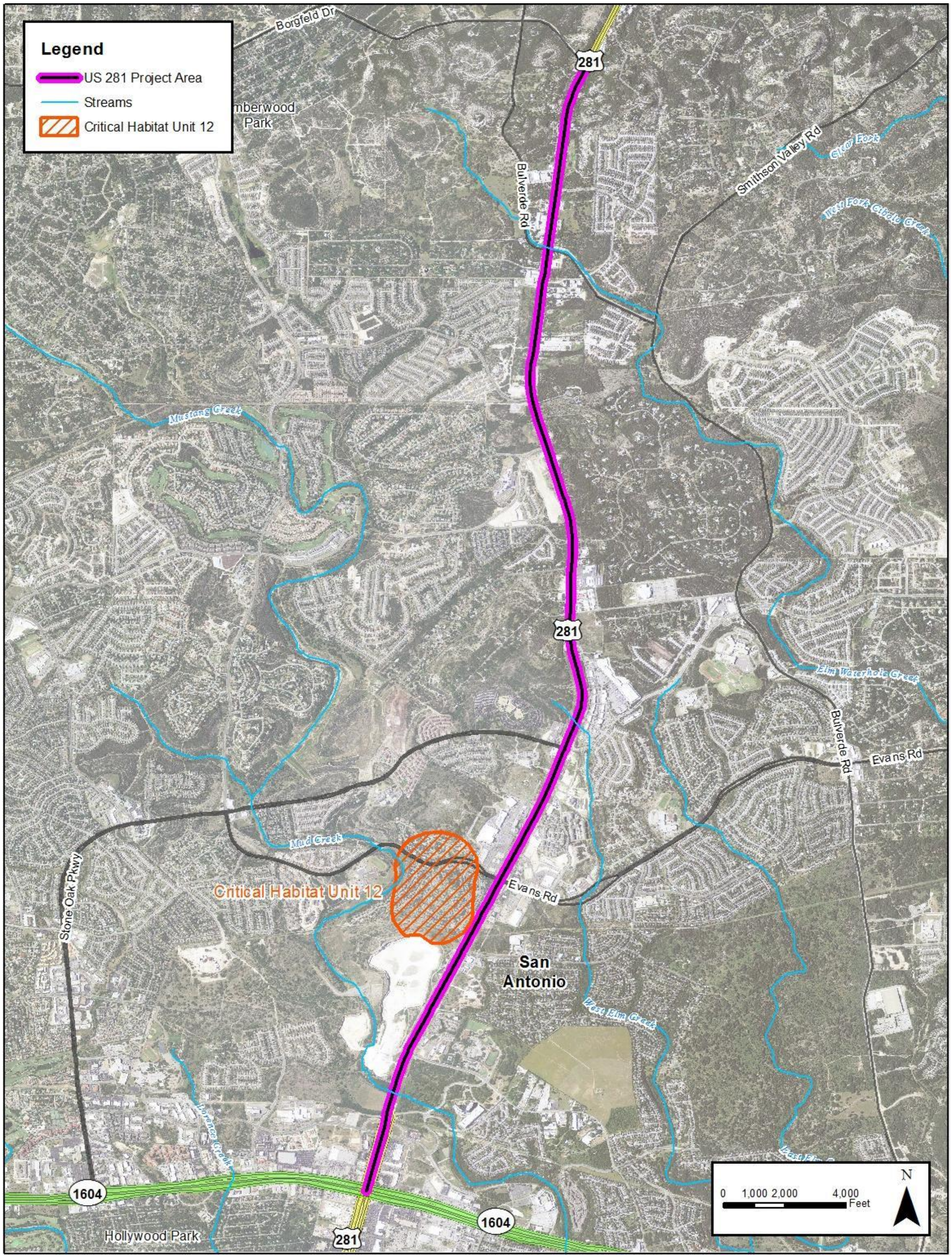


83

84 Source: George Veni & Associates 1994, 2003, USFWS 2012; US 281 EIS Team 2014 (December).

85

Figure 2-7: Critical Habitat Unit 12 within the project area



Source: USFWS 2012, US 281 EIS Team 2011 (July).

Figure 2-8: Critical Habitat Unit 12

Source: USFWS 2012; US 281 EIS Team 2014 (November).

Figure 2-9: Outer edge of Critical Habitat Unit 12 within exiting ROW

Figure 2-10: Hairy Tooth Cave within Critical Habitat Unit 12

2.3.2 Status of the Potentially Affected Golden-cheeked Warbler

Description

The GCWA is a small, neotropical songbird in the family Parulidae. Male GCWAs have a black back, throat, upper breast, and crown, white belly, black-streaked sides, white wing bars, and a black line through the eye with large yellow patches both above and below the eye. Female and immature GCWAs are duller, with olive upperparts with dark streaks and a yellowish or white chin (NatureServe 2012).

Habitat

According to the recovery plan, the GCWA inhabits two distinctly different habitat types: closed-canopy Ashe-juniper woodland in central Texas and pine-oak woodland in the highlands of southern Mexico to

Nicaragua (USFWS 1992). The Ashe juniper-oak woodland is the breeding habitat for the GCWA in Central Texas. The GCWA nests only in climax stage woodlands with a high proportion of mature Ashe juniper trees interspersed with other deciduous species, and prefer areas with a moderate to high tree density with dense foliage in the upper levels (USFWS 1992). According to Ladd and Gass (1999), forest stands where GCWAs are typically found average about 40 years in age and 20 feet in height with about 70 percent canopy cover and a tree density of 400 trees per acre. The TPWD defines habitat as containing Ashe juniper minimally 15 feet tall with an average canopy height of 20 feet, canopy cover of 35 percent and containing at least 10 percent oaks (Campbell 2003). Klassen (2011) demonstrates that this can vary throughout the warbler's range as she documents successful Kinney and Edwards County (southwest extreme of the GCWA range) breeding in areas with 20–25 percent canopy closure containing as low as three percent oaks.

The mature Ashe juniper is a key habitat feature for the GCWA since the main component in the species' nest is strips of bark from aged juniper trees. The loose, stringy bark found in the species' nest is only observed in older, mature trees, which accounts for the reliance of the GCWA on mature Ashe juniper stands. A study by J.C. Kroll (1980) found that Ashe juniper trees began sloughing bark near the base of the tree by 20 years of age and by the crown at 40 years. A few other factors may contribute to an improved habitat for GCWAs. Ladd (1985) noticed that the suitable habitat for the species coincided with steep canyons or rugged slopes, but nests are not limited to canyons (Guilfoyle 2002). GCWAs may be associated with canyon slopes because of a combination of other factors influencing the habitat quality: (1) greater surface run-off and seepage, which favors growth of preferred tree species and increases arthropod availability, (2) protection from wildfires, or (3) increased protection against the threat of clearing due to the high cost that comes with clearing steep slopes (USFWS 1992).

More recent studies indicate an important relationship between the size of habitat patches and warbler demographics such as presence and abundance within the patch. Coldren (1998) and Baccus et al. (2007) have found that GCWA abundance increases and territory size decreases linearly with patch size. Further, research indicates pairing and territory success both correlate positively to patch size. Patches of suitable oak-juniper habitat exceeding 247 acres are considered prime habitat (Arnold et al. 1996, Coldren 1998, Butcher et al. 2010, Morrison et al. 2010). Specifically, Arnold et al. (1996) found warblers were not reliably found in patches smaller than 57 acres and Butcher et al. (2010) suggest patch sizes ranging from 37 to 68 acres to be minimums for reproductive success. In addition to patch size, the amount of mature mixed woodland in the landscape is considered to be the most important predictive landscape-scale variable to GCWA occurrence (Magness et al. 2006).

Life history

The GCWA was discovered and first collected by Osbert Salvin in Guatemala in 1859 and later described by Philip Lutley Sclater of the British Museum and Salvin in 1860 (Pulich 1976, USFWS 1990 and Groce et al. 2010). The first Texas specimen collected was in 1864 near the confluence of the Medina and San Antonio Rivers in Bexar County, Texas, and the first GCWA nest was found in 1878 in Comal County. The GCWA was federally listed as an endangered species on May 4, 1990, by means of emergency rule. The final rule listing the GCWA as endangered under the ESA was published on December 27, 1990 (Pulich 1976, USFWS 1992 and Groce et al. 2010). In February 1991, the species was designated as endangered by the State of Texas (USFWS 1992).

The GCWA winters in southern Mexico (State of Chiapas) and in the Central American countries of Guatemala, Honduras, and Nicaragua (USFWS 1992). The species breeds only in the mixed Ashe juniper–oak woodlands of Central Texas. Of all the avian species known to occur in Texas, the GCWA is the only species whose breeding range is completely limited to the state. The GCWA generally begins to arrive on the breeding grounds in central Texas in late February and early March. The migration route of the GCWA follows the coniferous-oak highlands of the Sierra Madre Oriental (NatureServe 2012). The majority of the adults and fledglings leave the breeding grounds and begin the southward migration back to the subtropics in late June to July.

The GCWA is an insectivorous hopping and gleaning species, consuming lepidopteran larvae and non-lepidopteran winged insects (Groce et al. 2010) with beetles, caterpillars, Homopterans, Hemipterans, and spiders being their most common prey items (USFWS 1992). Much of the foraging time of the GCWA on the breeding grounds is spent gleaning for insects by moving from branch to branch within the upper portions of the woodland canopy, particularly in oaks (USFWS 1992, Groce et al. 2010).

Population dynamics

Pulich (1976) considered 31 counties located in Texas to be the nesting range of the GCWA: Bandera, Bell, Bexar, Blanco, Edwards, Erath, Comal, Coryell, Eastland, Bosque, Burnet, Gillespie, Hamilton, Hays, Hood, Johnson, Kendall, Kerr, Kimble, Kinney, Lampasas, Llano, Medina, Palo Pinto, Real, San Saba, Somervell, Stephens, Travis, Uvalde, and Williamson. He estimated the entire GCWA population in 1974 to be between 15,000 and 17,000 individuals. In 1990, suitable habitat for the species was estimated throughout both urban and rural sections of Texas, and based on available breeding habitat, it was determined that Texas could only support 4,800 to 16,000 breeding pairs (USFWS 1990). It was estimated that only 2,200 to 4,600 breeding pairs remained in 1990 (NatureServe 2012). Morrison et al. (2010) reported range wide presence of 4,148,138 acres of potential GCWA habitat in 63,616 patches, the majority of which were less than 25 acres in size. Mean patch size was greatest in USFWS Recovery Regions 5, 6, and 8. The US 281 action area falls within GCWA recovery Region 6, which includes all or portions of Bexar, Bandera, Kerr, Kendall, Gillespie, Blanco, and Comal Counties.

The 2006 range map published by TPWD shows the GCWA as having a potential or known presence in 44 counties in Texas. Currently, the USFWS distribution map for the GCWA shows the species as being present in 37 counties in Texas on the Lampasas Cut Plain, the Edwards Plateau, and the Llano Uplift regions of Texas. The largest concentration of GCWAs is located in the Balcones Fault Zone (USFWS 1992). Numerous state and federal properties totaling over 126,000 acres are within the breeding range of the GCWA. These include parks, natural areas, and recreation areas owned by the State of Texas and military reservations, areas surrounding lakes and a national wildlife refuge owned by the federal government (USFWS 1992). Of the 29 properties owned by the state or federal government within the range of the GCWA, 16 have the GCWA present. In addition, other entities such as the Lower Colorado River Authority, counties (Bexar, Travis, Williamson and Hays), and local municipalities such as the City of Austin also own property occupied by and/or managed for the GCWA (USFWS 1992).

GCWA Breeding/Reproduction

Researchers have found a wide variety in breeding territory sizes for the GCWA. Depending on the location and quality of habitat, GCWAs forage and nest in areas ranging in size from 5 to 20 acres per pair and males often return to the same nesting territory in subsequent years (USFWS 1992). Other studies have yielded territory sizes ranging from roughly seven to 57 acres in size to one to seven acres in size (Groce et al. 2010). It is important to note that, although territories are relatively small in size, recent studies indicate that much larger patch sizes are necessary for reliable occurrence (57 acres) and reproductive success 37 to 68 acres (Arnold et al. 1996 and Butcher et al. 2010).

Female GCWAs begin building nests the first week of April. The nests consist of bark from the Ashe juniper tree that is secured by cobwebs and lined with feathers, grass, oak leaves, etc. When finished, the nest is a small, compact cup averaging 3 inches outside diameter and 2 inches outside depth (USFWS 1992). Pulich (1976) found that females usually place the nest in the upper two-thirds of Ashe juniper trees. While juniper trees are the most common tree used as nesting sites, the species has also been found to place their nests in cedar elms, various oaks, pecans, and other species (USFWS 1992). The female

GCWA will perform all duties associated with incubation, which begins on the day before the last egg is laid and lasts 12 days. The female spends at least 75 percent of daylight hours on the nest (USFWS 1992).

Status and distribution

Reason for listing. Historically, habitat loss and fragmentation were the major reasons for the decline in the GCWA population. A juniper eradication program was implemented in Texas in 1948, and from the 1950s to the 1970s, about 50 percent of the juniper acreage was cleared for pasture improvement and urbanization (USFWS 1990). Several counties that had GCWA habitat, including portions of Gillespie County and all of Mason County, no longer contained suitable habitat by the 1970s (USFWS 1990). The current threat to the Ashe juniper-oak woodland is urban sprawl, growth of urban areas with known GCWA populations such as the city of Austin, and the conversion of wooded areas to agricultural land. In 1992, 60 percent of the remaining warbler habitat was located in the fastest urbanizing counties of Texas such as Travis, Bexar, and Kerr (Sexton 1992). Because of the growth and development in this corridor, the greatest rate of GCWA habitat loss has occurred in the southern and eastern portions of the Edwards Plateau (USFWS 1990). According to the GCWA recovery plan other major threats to the species include the creation of impoundments for flood control and livestock, loss of winter and migration habitat, destruction of oaks by oak wilt, over-browsing by livestock and white-tailed deer, nest parasitism, and habitat fragmentation (USFWS 1992).

Range wide trend. The most serious problems facing the Golden-cheeked Warbler today, as in the recent past, are habitat loss and fragmentation. Since warblers have limited and specific habitat requirements, direct habitat loss has resulted in population reduction, although precise comparisons of historic and current populations are not available.

Recently, serious losses in nesting habitat have occurred in counties such as Travis, Williamson, and Bexar, where rapid urban development has spread into oak-juniper woodlands associated with canyonlands. Flood control and other impoundments have also reduced habitat for the warbler by inundating the juniper-oak woodlands existing on canyon slopes and bottoms along springs, streams, and rivers. Construction of large reservoirs has also led to loss of warbler habitat due to development of lake-side communities (USFWS 1996).

The GCWA recovery plan identifies criteria to be met for the warbler to potentially be down-listed from endangered to threatened. Overall, these recovery criteria require the protection of sufficient breeding habitat to ensure the continued existence of at least one viable, self-sustaining warbler population in each of the eight recovery regions delineated in the recovery plan, where the potential for gene flow exists across regions to ensure long-term viability of the protected populations. Other key recovery strategies for the GCWA include the identification and protection of "focal areas" that include a single, viable warbler population or one or more smaller populations that are interconnected; and protecting and managing abundant and scattered patches of habitat outside of the focal protection areas (USFWS 1992).

In 1995, the USFWS sponsored a "Population and Habitat Viability Workshop" in Austin, Texas. One recommendation issuing from this workshop was to protect sufficient habitat for a carrying capacity of 3,000 breeding pairs for each GCWA recovery region. In addition, habitat measures within the regions were recommended and include prevention of habitat damage by herbivores, habitat restoration, maintenance of high percent canopy cover of trees, oak wilt prevention, predator and nest parasite control, limiting human impacts in habitat, and implementing landscape level planning (USFWS 1996).

In their Resource Assessment for the GCWA for the Southern Edwards Plateau Habitat Conservation Plan (SEP-HCP) Plan Area (Loomis Partners 2011), the authors state that conservation actions in the Plan Area that would be consistent with achieving recovery of the species in USFWS Recovery Region 6 might require the permanent protection and management of approximately 75,000 acres of relatively high-quality GCWA habitat. This broad estimate is based on achieving a protected population of 3,000 pairs at an average density of approximately four pairs per 100 acres, which is the long-term average density of the species recorded on Camp Bullis (Loomis Partners 2011).

Critical habitat

Critical habitat has not been defined for the GCWA by the USFWS.

2.4 SUMMARY OF LISTED SPECIES SURVEYS CONDUCTED IN THE PROJECT AREA

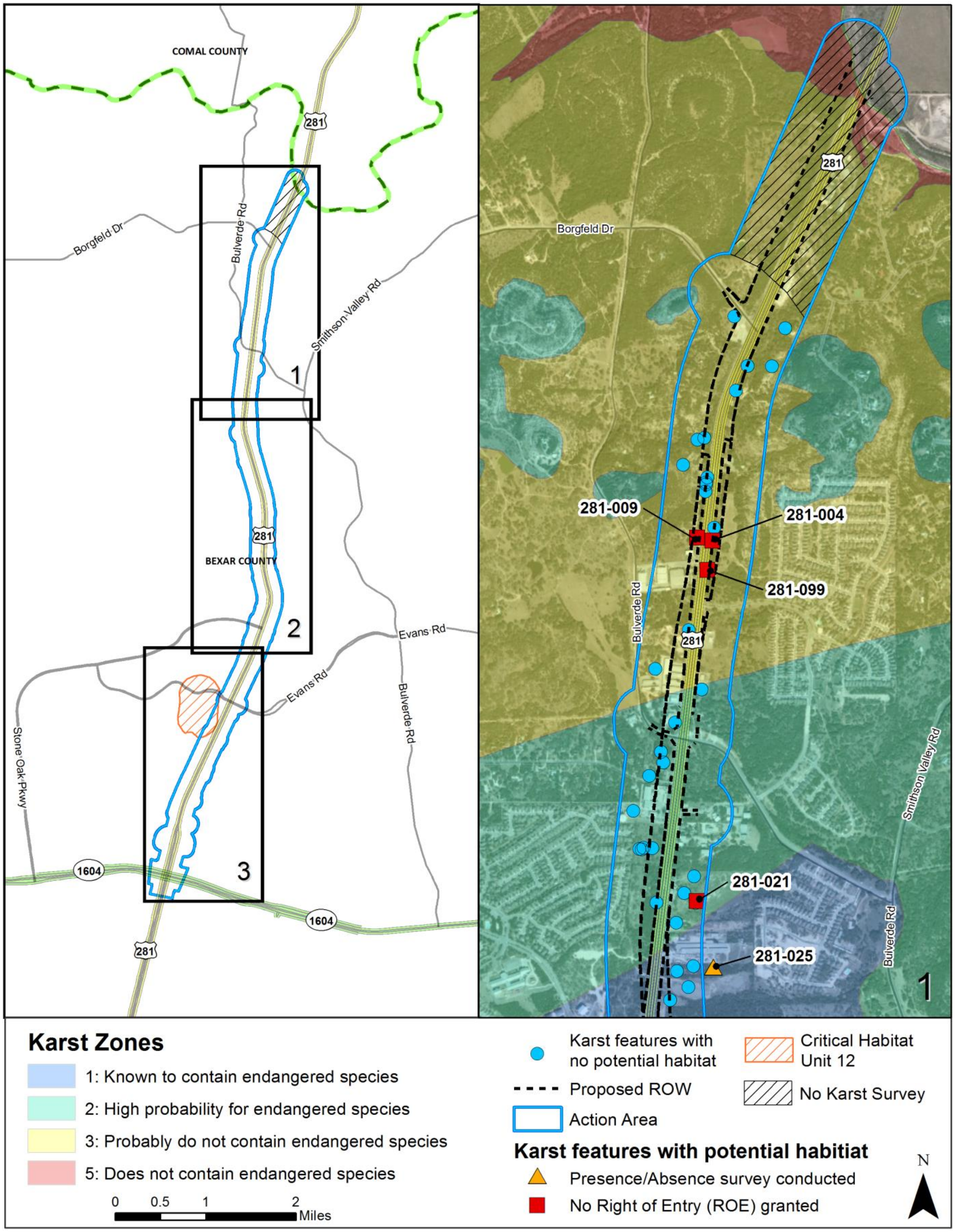
2.4.1 Terrestrial Karst Species

Field surveys and background research to assess potential endangered karst invertebrate species habitat were conducted in the vicinity of anticipated improvements to US 281 between Loop 1604 and Borgfeld Drive in Bexar County, Texas. Background literature searches provided information on one cave where access was not granted, but where previously conducted fauna surveys did not detect any endangered karst invertebrate species. Three caves that appear to have been covered up by roadways or development are no longer accessible, and no fauna surveys are known from them.

Surveys were conducted within the existing ROW and up to 500 feet beyond the ROW where access was granted from Loop 1604 to 500 feet north of Borgfeld Drive. Karst feature surveys were performed between December 2009 and November 2010 in accordance with USFWS 2006 protocols in effect at the time of surveys (USFWS 2006). A total of 116 features were recorded during field surveys. Some of these were non-karstic, others were karstic but not considered potential habitat, some were excavated to evaluate potential for karst invertebrate habitat, and some were open caves. Sixty features were recommended for excavation; 15 excavation requests were not granted by landowners, and the other 45 were excavated and reevaluated for their habitat potential. These reevaluations led to the identification of 13 caves and karst features that were determined to contain potential habitat and were therefore surveyed for listed karst invertebrate species (**Figure 2-11a, Figure 2-6b**, **Table 2-3**). Presence/absence surveys for federally listed karst invertebrates were conducted between June 14, 2010, and October 10, 2010. Ten of the features surveyed contained non-listed troglobites, and therefore are considered to be karst invertebrate habitat. Two caves within the project area are occupied by rare, non-listed species; they are Power Pole Hole and Stafford Cave. No federally listed karst invertebrate species were encountered during this study. More details regarding the survey effort are provided in the *2011 Karst Invertebrate Technical Report* (Zara 2011a) included in **Appendix B**.

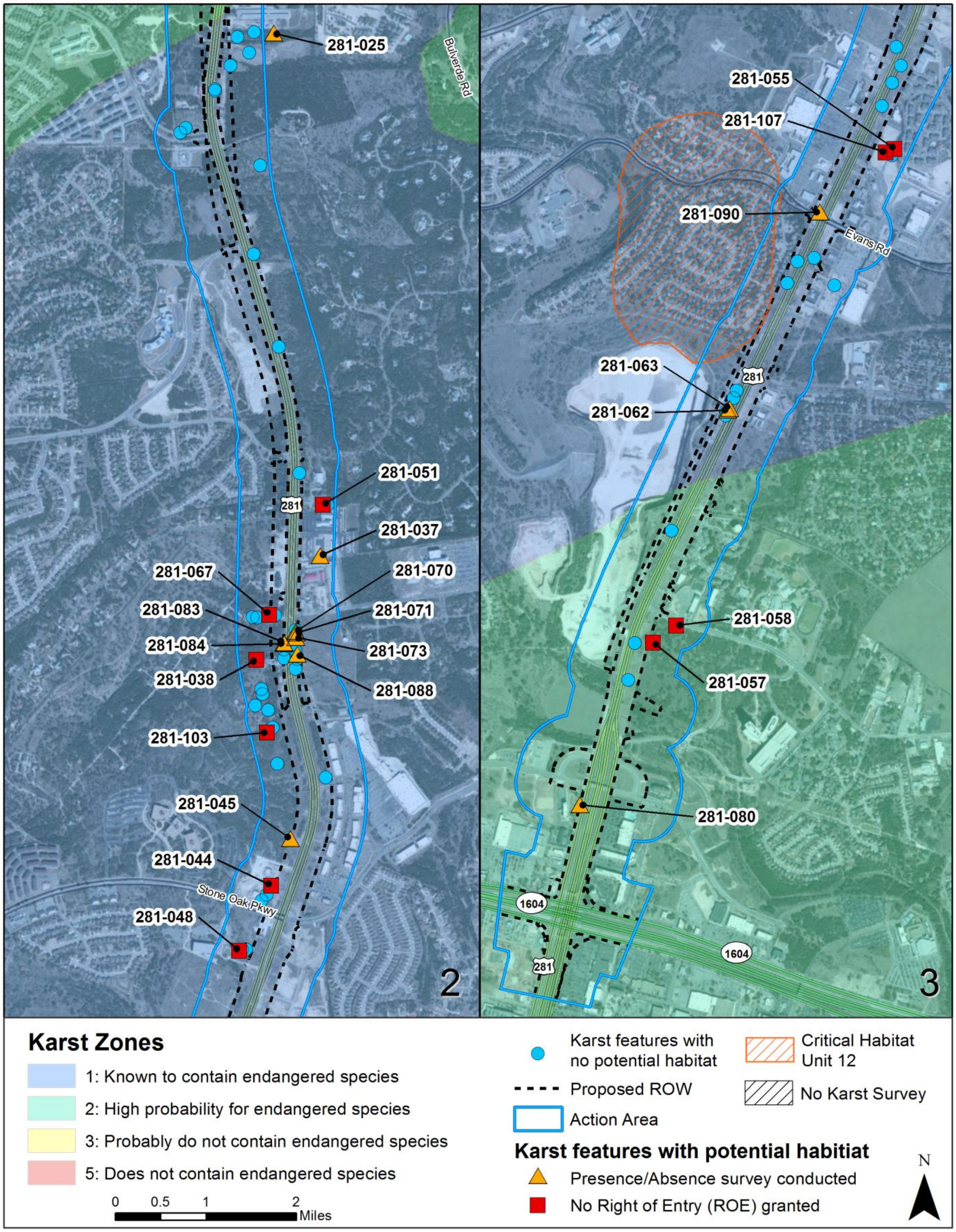
In addition to caves and karst features, one spring was surveyed for salamanders. No *Eurycea* salamanders were encountered. Two additional springs were recommended for biological surveys but access was not granted.

Figure 2-11a: Karst feature survey results



Source: George Veni & Associates 2003; Zara Environmental LLC 2011a (Appendix B), US 281 EIS Team 2014 (December).

279 Figure 2-6b: Karst feature survey results



280

281 Source: George Veni & Associates 2003; Zara Environmental LLC 2011a (Appendix B), US 281 EIS Team 2014 (December).

Table 2-3: US 281 Karst Features with potential karst invertebrate habitat.

Feature	Potential Habitat?	Presence/ Absence surveys?	Subterranean species	Comments
281-004	Y	N		Recommended for excavation but ROE not obtained.
281-009	Y	N		Recommended for excavation but ROE not obtained.
281-021	Y	N		Recommended for excavation but ROE not obtained.
281-025	Y	Y	Cave crickets: *Ceuthophilus cunicularis, Ceuthophilus secretus* Millipedes: *Cambala speobia* Spiders: *Cicurina* sp.(immature) Snails: *Helicodiscus* sp.	
281-037	Y	Y	Cave crickets: *Ceuthophilus* sp. Spiders: *Cicurina* undetermined Subterranean silverfish: *Texoreddellia* sp. Snails: *Helicodiscus* sp.	
281-038	Y	N		Recommended for excavation but ROE not obtained.
281-044	Y	N		Partially excavated but ROE revoked.
281-045	Y	Y	Cave crickets: *Ceuthophilus secretus* Spiders: *Cicurina* sp.(immature)	
281-048	Y	N		Recommended for excavation but ROE not obtained.
281-051	Y	N		Recommended for excavation but ROE not obtained.
281-055	Y	N		Recommended for excavation but ROE not obtained.
281-057	Y	N		Recommended for excavation but ROE was rescinded.
281-058	Y	N		Recommended for excavation but ROE was rescinded.
281-062	Y	Y	Subterranean silverfish: Nicoletiidae genus and species Terrestrial isopods: *Brackenridgia* Harvestmen: *Chinquipellobunus* sp. Millipedes: *Cambala speobia*	
281-063	Y	Y	Terrestrial isopods: *Brackenridgia* Slender diplurans: Campodeidae genus and species Subterranean silverfish: *Texoreddellia* sp.	
281-067	Y	N		Recommended for excavation but ROE not obtained.

Table 2-3: US 281 Karst Features with potential karst invertebrate habitat.

Feature	Potential Habitat?	Presence/ Absence surveys?	Subterranean species	Comments
281-070	Y	Y	Cave crickets: *Ceuthophilus cunicularis, Ceuthophilus secretus* Spiders: *Cicurina varians* Harvestmen: *Texella* Subterranean silverfish: *Texoreddellia* sp. Springtails: *Pseudosinella violenta*	
281-071	Y	Y	Cave crickets: *Ceuthophilus* sp. Terrestrial isopods: *Brackenridgia* sp.	
281-073	Y	Y	Cave crickets: *Ceuthophilus cunicularis* Slender springtails: Entomobryomorpha undetermined Spiders: *Cicurina varians* Subterranean silverfish: *Texoreddellia* sp. Springtails: *Pseudosinella violenta* Terrestrial isopods: *Brackenridgia* sp.	
281-080	Y	Y	Spiders: *Cicurina bullis, Cicurina varians* Scorpions: *Pseudouroctonus reddelli* Centipedes: Geophilomorpha undetermined Millipedes: *Cambala speobia* Slender springtails: Entomobryomorpha undetermined Cave crickets: *Ceuthophilus cunicularis* Snails: *Helicodiscus* sp. Terrestrial isopods: *Brackenridgia* sp. Pseudoscorpions: Pseudoscorpionida undetermined (eyeless) Harvestmen: *Chinquipellobunus* sp. (troglobite) Subterranean silverfish: *Texoreddellia* sp.	
281-083	Y	Y	Spiders: Araneae undetermined (eyeless) *Cicurina varians* Slender springtails: Entomobryomorpha undetermined Subterranean silverfish: *Texoreddellia* sp. Cave crickets: *Ceuthophilus* sp.	
281-085	Y	Y	Cave crickets: *Ceuthophilus* sp. Spiders: *Cicurina* sp. (eyed) Centipedes: Cryptopidae (*Theatops* sp.)[1] Terrestrial isopods: *Brackenridgia* sp.	

Table 2-3: US 281 Karst Features with potential karst invertebrate habitat.

Feature	Potential Habitat?	Presence/ Absence surveys?	Subterranean species	Comments
281-088	Y	Y	Cave crickets: *Ceuthophilus cunicularis*, *Ceuthophilus secretus*	
281-090	Y	Y	Subterranean silverfish: *Texoreddellia* sp.	
281-099	Y	N		Recommended for excavation but ROE not obtained.
281-103	Y	N		Recommended for excavation but ROE not obtained.
281-107	Y	N		Recommended for excavation but ROE not obtained.
281-109	Y	N		Recommended for excavation but ROE not obtained.

Source: Zara Environmental LLC 2011 (Appendix B).
[1] – Genus level identification is not certain. Based on identification by James Reddell (Appendix B)

2.4.2 Golden-cheeked Warbler

A habitat assessment performed in 2009 identified potential GCWA habitat in the US 281 project area. After three years of survey effort during 2009, 2010 and 2014, no GCWA were detected; however, habitat losses continue due to current and pending development in the US 281 project corridor. Summaries of the surveys are below and the 2009, 2010, and 2014 presence-absence survey reports for the GCWA are included in **Appendix C**.

2009 Habitat Assessment and Survey (Blanton & Associates)

No habitat for the GCWA was identified in the existing US 281 ROW, but 13 blocks of potential GCWA habitat totaling approximately 230 acres were identified in proposed ROW and/or the project area within a 500-foot buffer surrounding the existing and proposed ROW. No habitat was identified for any other endangered songbird, most notably the Black-capped Vireo (*Vireo atricapilla*). A presence-absence survey for the GCWA was conducted in accordance with USFWS protocol on parcels within the 13 GCWA habitat blocks during spring 2009 where right of entry (ROE) was granted. No surveys were conducted in blocks 5, 8, or 10. After field review of the original 13 habitat blocks, it was determined that three of these blocks (4, 10, and 11) did not contain suitable habitat due to a variety of reasons.

No GCWAs were observed or heard during the survey. Eighty-two other avian species, representing 32 families, were detected during the survey. The most common species included the Northern Cardinal (*Cardinalis cardinalis*), Bewick's Wren (*Thryomanes bewickii*), Carolina Wren (*Thryothorus ludovicianus*), Black-crested Titmouse (*Baelophus atricristatus*), Carolina Chickadee (*Poecile carolinensis*), Northern Mockingbird (*Mimus polyglottos*), Western Scrub Jay (*Aphelocoma californica*), White-winged Dove (*Zenaida asiatica*), Mourning Dove (*Z. macroura*) and Turkey Vulture (*Cathartes aura*) (Blanton & Associates 2009).

2010 Survey (Hicks & Company)

The habitat assessment conducted in spring 2009 originally delineated 13 blocks of potential habitat for the GCWA. After the 2009 survey, blocks 4, 10, and 11 were determined to not contain suitable habitat. After aerial photo and field reconnaissance, Hicks & Company ecologists agreed with these conclusions and replicated the survey conducted in the previous breeding season in the remaining ten blocks where ROE was granted. Blocks 3, 5, 8, and 13 were not surveyed in 2010. Ashe juniper clearing rendered some additional tracts non-habitat, and removed portions of several blocks from consideration as habitat (block 6); however, surveys were conducted in approximately 124 acres of representative samples within a majority of the blocks where habitat was still present and surveyors checked all additional habitat available from public ROW during the effort.

No GCWAs were detected by call or visual observation during the 2010 presence/absence survey. A total of 51 avian species in 29 families were detected. The most commonly observed species included Carolina Chickadee, Black-crested Titmouse, Carolina Wren, Bewick's Wren, Northern Mockingbird (*Mimus polyglottus*), Rufous-crowned Sparrow (*Aimophila ruficeps*), Northern Cardinal, Brown-headed Cowbird (*Molothrus ater*), and Lesser Goldfinch (*Carduelis psaltria*) (Hicks & Company 2010).

2014 Survey (Hicks & Company)

In early 2011, the Alamo RMA asked the USFWS for concurrence that sufficient survey effort for the GCWA was conducted along the project corridor to conclude absence. Subsequently, the USFWS provided a letter (see **Appendix D**) to the Alamo RMA concurring that two years of survey with negative findings for GCWA on US 281 was sufficient to conclude absence. However, there was a stipulation provided that survey might have to be updated if construction was not initiated within three years. Given this stipulation, a third season of survey was conducted in spring 2014.

On March 14, 2014, prior to the commencement of 2014 surveys, a field visit was conducted to reassess the habitat blocks. Approximately 32.14 additional acres of potential GCWA habitat was identified on the north end of the project limits and included in Block 2. Clearing of Ashe juniper was noted in Block 9. As in 2009 and 2010, ROE was not granted to all potential habitat within the project corridor; however, surveys were conducted in approximately 125 acres of representative samples within six of the ten blocks where habitat was still present (blocks 1, 2, 6, 7, 9, and 12) and surveyors checked all additional habitat available within existing ROW during the effort. No surveys were conducted in blocks 3, 5, 8, or 13 due to lack of ROE.

No GCWAs were detected by call or visual observation during the 2014 presence/absence survey. A total of 45 other avian species, representing 24 families, were detected during the survey. The most commonly observed species included Carolina Chickadee, Black-crested Titmouse, Carolina Wren, Bewick's Wren, Northern Mockingbird, Northern Cardinal, Brown-headed Cowbird, and Lesser Goldfinch.

After three years of effort, no GCWA have been detected and habitat quantity and quality losses continue due to current and pending development and both man-induced and natural woodland losses in the corridor. Ashe juniper clearing has taken place in four habitat blocks and significant oak mortality has been observed on the west side of US 281 due to hypoxylon canker; a naturally occurring fungal condition particularly expressed in oaks during periods of environmental stress. In addition, nesting deterrents for the GCWA are prevalent and likely increasing due to urbanization, noise, and the prevalence of typical nest predator and social parasite species such as the Western Scrub Jay, Great-tailed Grackle, and Brown-headed Cowbird. Given the negative survey findings to date and increasing downward spiral of habitat quality, it does not seem likely that the GCWA will utilize the project corridor, although some potential habitat has not been surveyed. Overall, potential affects to the GCWA are expected to be insignificant and discountable.

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Chapter 3

Effects Analysis and Conservation Measures

3.1 EFFECTS ANALYSIS

3.1.1 Direct Effects

Direct effects are those caused by the proposed project and occur at or very close to the time of the action itself. Direct effects are confined to the project footprint; however, as the design for the project is preliminary, direct effects are assessed within the existing and proposed ROW for the proposed project (**Appendix A**). Habitat for four federally listed species was identified within the existing and proposed ROW of the proposed project. These species include *C. madla*, *R. exilis, R. infernalis*, and the GCWA. Direct effects to each of these species are discussed below.

Karst Invertebrates

Direct effects to karst invertebrate habitat may also occur due to surface disturbances such as vegetation removal, which may result in fragmentation of trogloxene (e.g. cave crickets) foraging areas, alterations in nutrient input and outflow, reduction in the carrying capacity of karst habitat, and the introduction of invasive species (e.g. red imported fire ant). Up to 172 acres of wooded and unmaintained vegetation would be removed by the proposed project. The majority of this vegetation is located within karst zone 1 (103 acres), followed by 35 acres in karst zone 2, 33 acres in karst zone 3 and 1 acre in karst zone 5.

Other direct effects to karst invertebrate habitat occur within and adjacent to the project area due to the placement of impervious cover (bridge decks, roadway surfaces, etc.) and alterations in surface and subsurface drainage that may result in changes to previously stable temperature and moisture regimes in karst habitat. Approximately 98 acres of impervious cover will be added by the proposed project.

The proposed project may result in direct impacts to karst invertebrate species due to the disturbance and removal of subsurface habitat by geotechnical borehole drilling, pier drilling, surface milling, grading, and excavation. Any of these activities may entirely or partially remove a subsurface void in bedrock that contains habitat for karst invertebrate species. In cases where voids are mostly intact, exposure of subsurface habitat can cause climate alteration such as temperature swings, desiccation, or flooding. Further explanation and quantification of subsurface habitat disturbance due to construction activities is discussed in detail below.

Geotechnical Borehole Impacts

Geotechnical boreholes are typically small diameter (2 to 12 inch) holes that do not result in total destruction of karst voids. The depth of geotechnical boreholes can vary between 30 and 70 feet depending on the needs of the project. When a void is encountered in a borehole, the drill bit will penetrate the ceiling or wall of the void, causing some debris (drilling tailings) and water (if used as a bit lubricant) to enter the void. Voids can be detected during drilling by a bit drop or change in drilling pressure. Voids can be assessed using a downhole camera for the presence of karst invertebrate habitat (**Figure 3-1**). If habitat is present, baiting and trapping of karst invertebrates to determine presence or absence may be possible depending on the size and configuration of the void. As voids encountered in geotechnical boreholes are located at some depth within a borehole, the potential for climate alteration is minimal. Drilling of the borehole may induce airflow to subsurface voids; however, a narrow opening, typical of most boreholes would not result in as much desiccation as would occur if the void were directly exposed to the surface. Boreholes are typically plugged with bentonite clay, or backfilled with the material removed to prevent the introduction of potentially contaminated surface runoff into groundwater. Voids within boreholes may be preserved by plugging the borehole above the void.

Figure 3-1: A subsurface void intersected by a geotechnical borehole as viewed with a downhole camera

Pier Drilling Impacts

Drilling for the installation of support piers for bridges and ramps involves drilling larger shafts ranging from 3 to 15 feet in diameter with depths typically between 12 and 40 feet. Drilled shafts for piers have the potential to entirely destroy a karst void, or remove a significant portion of it, depending on the diameter of the shaft. A void encountered in a drilled shaft may be exposed to significant climate alteration, though perhaps not as much as in the cases of milling and excavation (**Figure 3-2**).

Figure 3-2: A three-foot diameter drilled pier shaft intersecting a subsurface void

Surface Milling and Grading Impacts

Surface milling is used to evenly lower the grade of bedrock by several inches at a time over wide areas to provide an even surface for subgrade layers in roadway projects. As a milling machine passes over an area it removes surface bedrock and leaves behind a pile of cuttings including small rocks and dust (**Figure 3-3**). Cuttings are then piled up by other machines and loaded into dump trucks for removal or reuse. The milling machine operator does not have a good view of the milling action and may not know if a void has been encountered. Graders are also used to scrape materials from the ground surface after milling to achieve a particular slope. When the area is scraped free of debris the void should become apparent, unless the void is completely destroyed by milling or grading equipment. Impacts to voids encountered by milling and grading activities will vary depending on the vertical and horizontal extent of the void, and whether the void is situated in the floor of the milled or graded area or in the wall. If a large portion of a void is exposed, climate alteration will be exacerbated. If only a narrow opening to void is created, climate alteration may be minimal. In either case, flooding can still occur on the floor of the downcut area, especially if it has the aspect of a large trench, channeling floodwaters.

Figure 3-3: Tailings from milling machines may conceal voids

Excavation Impacts

Excavation equipment such as trackhoes and trenchers are typically used in smaller areas than milling and grading equipment; however, the depths impacted may be greater. Most excavation and trench work on roadway projects is for the placement of stormwater conveyances and water quality facilities. Trackhoe operators typically have a good view of the excavation and can visualize voids as they are encountered (**Figure 3-4**). Trenchers come in two basic types, either a large wheel or a chainsaw-like arm, both with large rock-cutting teeth on them. Since the trench is narrow, visibility for detecting voids encounters in minimal. Voids exposed in excavations and trenches would be subject to similar climate alterations as those in pier drill holes, and would be particularly subject to flooding from rainfall runoff.

Figure 3-4: A trackhoe removing bedrock

Quantification of Subsurface Impacts

Subsurface habitat for federally listed endangered karst invertebrates occurs within the existing and proposed ROW. The probability of detecting listed karst invertebrate species varies by karst zone. Karst zones are explained in **Section 2.3.1** and mapped in **Figure 2-2**. Karst feature surveys in 2009 and 2010 recorded 116 features. These features do not include wells, faults, or potential karst features that were ultimately determined not to have been formed by karst processes. Portions of karst zone 3 north of Borgfeld Drive were not surveyed. The *2011 Karst Invertebrate Technical Report* (discussed in **Section 2.4.1** and included in **Appendix B**) details karst feature investigations and determinations related to each feature.

The acreage of each karst zone and total number of karst features that would be impacted as a result of the construction of the proposed project are listed in **Table 3-1**. A total of 57 of the 116 features identified are within the ROW of the proposed project, and would be removed as a result of construction. All except for three of the 57 features were fully evaluated and no listed karst invertebrates were encountered (**Table 2-3**). The three features (#281-004, #281-009, and #281-099) within the proposed ROW for the proposed project that are considered potential habitat were not fully evaluated due to having access denied by landowners (**See Section 2.4.1** Caves and karst features are also known to exist on some of the properties where landowners were unresponsive to requests for or denied access. Conclusions about the status of listed karst invertebrate habitat in those areas cannot be made at this time.

Table 3-1: Karst zone acreage and the number of karst features located within the ROW of the proposed project.

Karst Zone 1		Karst Zone 2		Karst Zone 3*		Karst Zone 4		Karst Zone 5*		Total Karst Features
acres	features	acres	features	acres	features	acres	features	acres	features	
225	37	134	9	85	11	0	0	3	0	57

Source: George Veni & Associates (2003, 1994); Zara Environmental 2011.
* - Karst surveys were not conducted north of Borgfeld Drive in portions of karst zones 3 and 5.

Engineers have attempted to quantify the amount of material that would be excavated in order to accomplish the proposed design based on preliminary schematics in **Appendix A**. Areas have been identified within karst zones 1, 2, and 3 where the removal of subsurface limestone that may intersect or remove voids containing potential habitat for karst invertebrates is necessary during construction activities. An estimated total 997,844 cubic yards of subsurface limestone in karst zones 1, 2, and 3 will be directly impacted by construction activities for the proposed project. This volume is broken down by activity and by karst zone in **Table 3-2**. The terrain in the US 281 corridor is very irregular transversely and longitudinally; therefore, anticipated maximum downcutting for roadway excavation ranges from 1 to 23 feet (**Table 3-2)**. Potential depths of impacts for other construction activities are also included in **Table 3-2**. Descriptions of roadway excavations by station number follow **Table 3-2**.

Table 3-2: Subsurface limestone removal by karst zone and by construction activity within the proposed project area.

Construction Activity	Karst Zone 2			Karst Zone 1			Karst Zone 2			Karst Zone 3			Activity Total
	Station Range[1] 324+00 to 392+75			Station Range 392+75 to 614+50			Station Range 614+50 to 653+00			Station Range 653+00 to 743+00			
	Excavation	Downward Cut		Excavation	Downward Cut		Excavation	Downward Cut		Excavation	Downward Cut		
	cubic yards	Min (ft)	Max (ft)	cubic yards	Min (ft)	Max (ft)	cubic yards	Min (ft)	Max (ft)	cubic yards	Min (ft)	Max (ft)	cubic yards
Geotechnical Borings	23	-	80	12	-	80	1	-	80	2	-	80	38
Bridge Foundation Drilled Shafts	5,119	-	50	4,813	-	50	471	-	50	659	-	50	11,062
Roadway Excavation	69,932	0	23	465,273	0	23	97,025	0	23	271,229	0	23	903,459
Drainage Culverts	3,566	6	15	10,599	6	15	3,812	6	15	2,375	6	15	20,352
Water Quality BMP	10,756	6	10	32,040	6	10	4,061	6	10	15,456	6	10	62,313
Cantilevered Noise Wall Foundations	0	0	0	620	0	12	0	0	0	0	0	0	620
Totals	89,396			513,357			105,370			289,721			997,844

1: Station Ranges correspond to Preliminary Schematic Drawings of the proposed project found in **Appendix A**
Source: US 281 EIS Team 2014 (November).

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The following descriptions of roadway excavation by station ranges correspond with Preliminary Schematic Drawings of the proposed project found in **Appendix A.** These descriptions are provided to better understand the proposed subsurface impacts relative to existing conditions and the information provided in **Table 3-2**.

Excavation Impacts in Karst Zone 2 from Station 324+00 to Station 392+75 (Appendix A - Sheets 1 and 2)

Excavation in karst zone 2 at the southern end of the project begins with construction of foundations for four direct connectors from Loop 1604 to US 281. Roadway excavation begins at station 342 with a maximum cut of three feet for the roadway pavement structure. By station 359, the entire roadway is on fill to station 362. At station 364, the northbound frontage road enters a cut to station 371 with a maximum cut of 23 feet. The southbound frontage road is also in a cut up to a depth of 12 feet. The main lanes are predominately on fill, but do have some cuts of up to three feet.

Excavation Impacts in Karst Zone 1 from Station 392+75 to Station 614+50 (Appendix A - Sheets 2 - 7)

The majority of the area for karst zone 1 between station 392+75 and station 614+50 will be filled as opposed to cut/excavated. Beginning at station 392+75, the southbound frontage road on the west side is in about a two foot cut and the remainder of the cross section is in a fill across the entire ROW. The majority of the section remains in a fill condition to station 397 where the northbound and the southbound frontage roads enter cut conditions of 0 to 6 feet deep up to station 406. The entire section is then at existing ground level and begins elevating onto fill. From station 409, the section meanders on shallow fill and cut up to station 421. The northbound frontage road then enters into a cut to station 426 ranging from 0 to 6 feet. At station 435, the southbound frontage road enters a cut of up to 7 feet through station 439. Beginning at station 453, the northbound frontage road enters a deep cut from 0 feet to 21 feet thru station 465. The southbound frontage road at station 455 enters a cut from 0 to 14 feet through station 470. The southbound frontage road enters a cut at station 473 of 0 to 10 feet to station 485. The northbound frontage road enters a cut at station 474 to 476 with a maximum cut of 12 feet. At station 480, the northbound frontage road enters a cut of 3 feet to station 482. From station 493 to station 619, typical cuts will be less than 4 feet and will occur on the southbound frontage road or the northbound frontage road. Some points where ditches are created, the cuts range up to 12 feet deep, but are only isolated in short distances of less than 200 feet. From station 602 to station 610, the cuts are across half of the ROW width and range from 0 to 8 feet in depth.

Excavation Impacts in Karst Zone 2 from station 614+50 to station 653+00 (Appendix A - Sheets 7 - 8)

The main lanes in karst zone 2 begin at station 614+50 in a fill condition and remain until station 620. At that point, they enter into a cut with a maximum depth of 6 feet, to station 641. The northbound frontage road also begins in a cut and continues to station 653 with maximum cuts of six feet for the ditches. From station 614+50 to station 646, the southbound frontage road is mostly in a shallow cut of up to three feet; however, the drainage ditches do cut as much as ten feet into the existing terrain. At station 646, the southbound frontage road emerges into a fill condition all the way to station 653.

Excavation Impacts in Karst Zone 3 from station 653+00 to station 743+00 (Appendix A - Sheets 8 - 10)

The terrain in karst zone 3 slopes steeply from the west to the east, which generally results in cuts on the west side and fills on the east side. In karst zone 3, the main lanes begin in a fill condition and continue to station 657. From station 657 to station 689, the main lanes enter into shall cuts of up to three feet. The main lanes begin entering a fill condition again at station 689 and continue to station 713 as they pass over Borgfeld Drive. At station 713, the main lanes enter a substantial cut of up to twenty-five feet and continue in a cut to station 727. At station 727, the main lanes are in a fill to station 730 and then enter a shallow cut as the main lanes merge back into the existing section at station 742. Both the southbound frontage road and the northbound frontage road begin in shallow cuts of up to three feet for the pavement structure. Ditches along both frontage roads will cut into the terrain to depths of three to five feet in a v-shape. As the northbound frontage road and the southbound frontage road proceeds northward, the pavement sections transition from a cut to a fill. The cuts in some smaller areas are up to ten feet. North of station 710 up to station 726, the northbound frontage road sections are in cuts of up to fifteen feet. At station 719, the southbound frontage road merges into the main lanes and at station 726, the northbound frontage road merges into the main lanes.

Analysis of Karst Invertebrates in Entranceless Voids

Certain karst invertebrate species may be more likely to be impacted by subsurface disturbances. Occupation of caves and karst voids (mesocaverns) by karst invertebrates may vary by species, and can be influenced by the nature of the cave or void. Karst invertebrate composition tends to be greater in caves with natural entrances and those surrounded by sinkholes that receive significant quantities of organic material carried in by runoff and transient fauna such as raccoons and cave crickets. However, previously entranceless voids encountered during subsurface disturbance have demonstrated the ability to support populations of troglobitic species.

In order to anticipate which karst invertebrate species would be likely to occur within entranceless voids that may be encountered during construction of this project, results of previous karst biology surveys conducted during construction of the US 281/Loop 1604 interchange were analyzed. (Zara 2011b, 2012a, 2012b, 2012c, 2012d, 2012e, 2012f, 2012g, 2012h). In 14 instances, voids encountered during construction were found to contain karst invertebrate species. Species included in the table are troglobites (cave obligates) with the exception of trogloxene *Ceuthophilus* cave crickets (**Table 3-3**). Cave crickets are included because their eggs are thought to be a food source for endangered *Rhadine* beetles; therefore, they could be an indicator for those species (Taylor et al. 2007). *Cicurina* species occurrences are specified as eyeless because eyed *C. varians* are often found in caves and karst voids, but are not troglobitic or endangered.

Table 3-3: Occurrence of troglobitic species and cave crickets found during void surveys at the US 281/Loop 1604 Interchange.

Feature name	Taxa
JCT 26 North B	*Texoreddellia* sp. *Cicurina* sp. eyeless
O4WB 21/22	*Texoreddellia* sp. *Ceuthophilus* sp.
AA-5A	*Texoreddellia* sp.
HH4B	*Texoreddellia* sp.
HH2C	*Texoreddellia* sp. *Ceuthophilus* sp.
ES23	*Texoreddellia* sp.
HH3	*Texoreddellia* sp. *Mixojapyx* sp. *Ceuthophilus* sp.
North Wall C (33)	*Texoreddellia* sp. *Ceuthophilus* sp.
WS Ramp 1 (36)	*Texoreddellia* sp.
South Wall C (39)	*Texoreddellia* sp. *Ceuthophilus* sp.
Blanco 2 (47)	*Texoreddellia* sp.

Feature name	Taxa
Aqualogic Cave	*Texoreddellia* sp. *Mixojapyx* sp. *Scolopendra* sp. Eyeless
Pancake Cave	*Texoreddellia* sp.
04-WB-30(10)	*Texoreddellia* sp. *Ceuthophilus* sp.

Source: Zara Environmental LLC 2011b, 2012a, 2012b, 2012c, 2012d, 2012e, 2012f, 2012g, 2012h.

This analysis shows that out of 14 previously entranceless voids containing troglobitic species, one contained eyeless *Cicurina* species. While *C. madla* does occur in the Stone Oak KFR, it is only known from the western edge of the KFR within Camp Bullis. Other non-listed *Cicurina* species that occur within the Stone Oak KFR and have been found in closer proximity to the proposed project include *C. bullis*, *C. platypus*, and *C. puentecilla*.

None of the previously entranceless voids in this analysis contained *Rhadine* species; however, six contained *Ceuthophilus* cave crickets which could be conducive to *Rhadine* habitation (Taylor et al. 2007). The project reports examined did not always specify which *Ceuthophilus* species was present; cricket nymphs can be difficult to assign to species without laboratory examination. The less common *Ceuthophilus* species encountered in Bexar County caves, *C. cunicularis*, does not leave the cave at night to forage; therefore, it would not necessarily need to live in proximity to an entrance (Taylor et al. 2005). The most common Bexar County cave cricket, *C. secretus*, must exit the cave at night to forage for food, and may roost in different shelters on consecutive nights, including newly opened voids (Taylor et al. 2005).

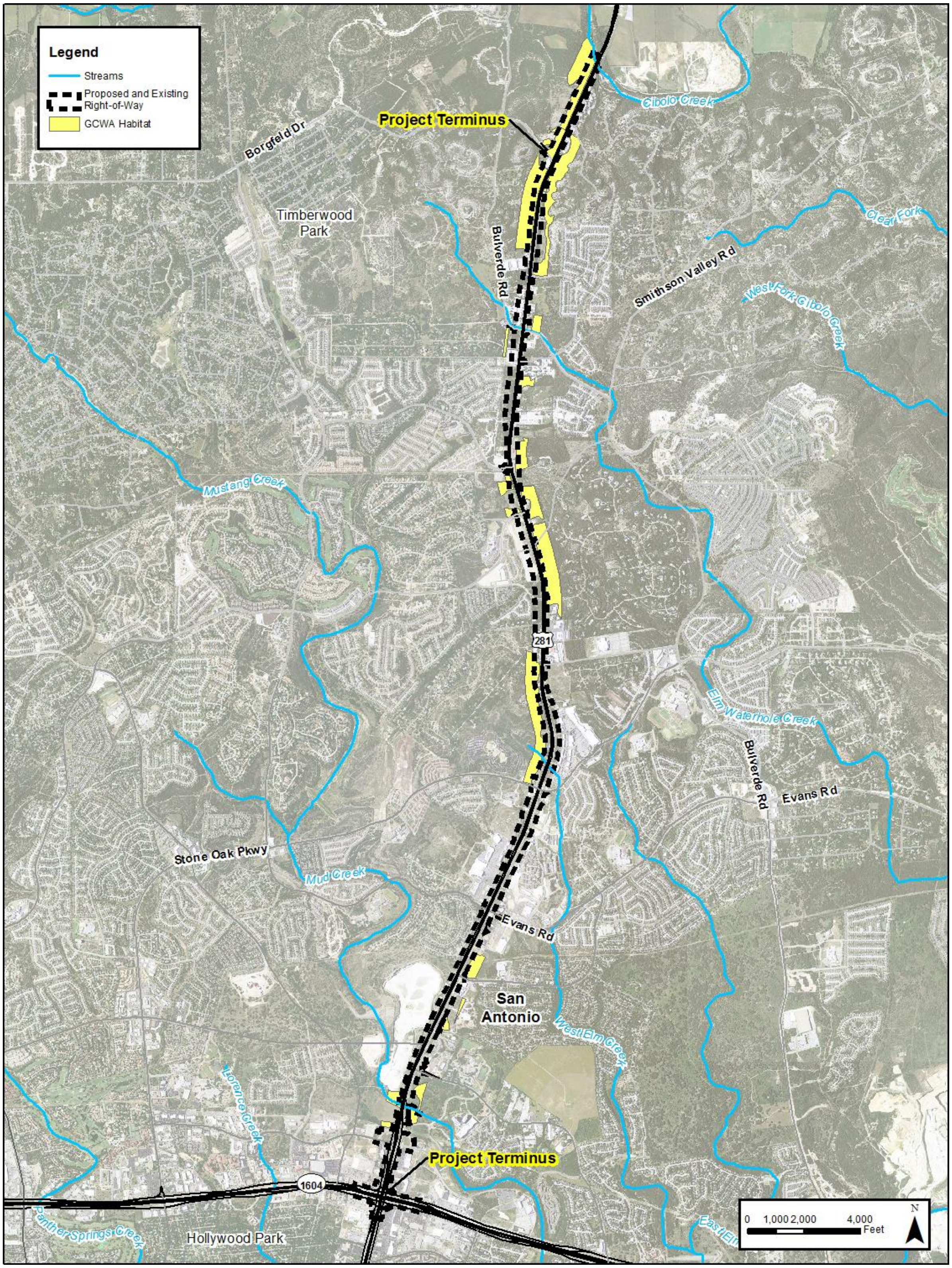
The association of *Rhadine* with cave cricket eggs could explain their absence from accidentally discovered voids. The large populations of *C. secretus* found in caves with natural sinkhole entrances could be important to *Rhadine* habitation. Krejca and Weckerly (2007) showed that 14 fauna surveys may be needed to detect *Rhadine* species where they are known to occur; however USFWS protocols at the time of the surveys included in this analysis only required three surveys; survey protocols were changed in 2014 to require 14 survey events (USFWS 2014c).

While habitat for federally listed karst invertebrate species may exist in the ROW, no federally listed karst invertebrate species were detected during presence/absence surveys conducted in 2010 for the US 281 Corridor Project and no listed karst species are known to historically occur within the surveyed area. The nearest recorded localities of federally listed karst species in the area are for *R. exilis,* which is known from Ragin’ Cajun Cave and Hairy Tooth Cave, both of which occur within CHU 12 (USFWS 2012). The closest confirmed location for *R. infernalis* is Genesis Cave, approximately 1.7 miles west of the US 281 project corridor, and there are no known localities within the US 281 karst survey area. The eastern limit of the currently understood range of *C. madla* is located seven miles west of the US 281 project area in Camp Bullis.

Golden-cheeked Warbler

Direct impacts to GCWA may include habitat loss, fragmentation, and/or degradation due to the clearing of mature Ashe juniper and native hardwoods, and increased edge effects which can leave GCWA vulnerable to nest predator and social parasite species such as the Great-tailed Grackle and Brown-headed Cowbird. A habitat assessment performed in 2009 identified potential GCWA habitat in the project area (**Figure 3-5**). GCWA utilize mature hardwood and Ashe juniper stands for nesting, feeding and roosting. The USFWS concurred that based on the survey results from 2009 and 2010, there is sufficient data to conclude that the GCWA is not likely to occur within the US 281 project area; however,

Figure 3-5: Potential GCWA habitat within the US 281 project area



Source: Blanton 2009 (Appendix C); US 281 EIS Team 2014.

the USFWS stipulated that additional survey work would be conducted if construction did not commence within three years. This decision is documented in a letter dated May 11, 2011, between the USFWS and the Alamo RMA (Appendix D). Because of this, a third year of surveys was conducted during the spring 2014 breeding season. No GCWA were detected.

Original estimates of habitat that would need to be cleared in the proposed ROW were as high as 65 acres; however, more refined design for the proposed project has reduced this estimate. Assuming that all GCWA habitat in the proposed ROW will be cleared to construct the proposed project, direct impacts to GCWA may occur due to the removal of approximately 44.74 acres of potential habitat. Therefore, due to the 39 acres of unoccupied habitat and the decline of habitat quality within and adjacent to the project corridor, any effect on GCWAs caused by the removal of the additional 5.1 acres of unsurvyed habitat are likely insignificant and discountable as a result of the proposed project. Additional GCWA habitat losses continue due to current and pending development along the US 281 project corridor independent of, and unrelated to the proposed project. Given the negative survey findings to date and decline of habitat quality, it is not likely that the GCWA will be directly affected by the removal of 39.64 acres of GCWA habitat known to be unoccupied. The removal of an additional 5.10 acres of habitat not surveyed, but unlikely to contain GCWA may result in insignificant and discountable effects to GCWA.

3.1.2 Direct Effects Take Assessment

It is anticipated that incidental take of *C. madla*, *R. exilis* and *R. infernalis* may occur as a result of the proposed project. Individuals of these species are difficult to detect unless observed undisturbed in their environment, and occupied karst features in this area are often undetectable until they are exposed from surface or bedrock disturbing activities. Because a precise mechanism for predicting the number of individuals that may actually be taken by the proposed project over time due to habitat loss is not available, potential incidental take is expressed by the extent of karst invertebrate habitat likely to be destroyed or disturbed.

The installation of geotechnical boreholes may directly affect listed karst species by removing approximately 38 cubic yards of subsurface limestone and/or intersecting potential karst habitat (**Table 3-2**). This action may result in take of listed karst species in the form of harm or harassment via directly killing or injuring individual animals, habitat degradation from temporary exposure of occupied features to surface air (forcing individuals to find new shelter with stable humidity and temperatures), and habitat modification due to the disruption of mesocavernous connectivity (resulting in individuals being prevented from traveling from point to point for feeding, breeding or sheltering).

Drilling shafts for bridge foundations may directly affect listed karst species by removing approximately 11,062 cubic yards of subsurface limestone or potential karst habitat in karst zones 1, 2, and 3 (**Table 3-2**). This action may result in take of listed karst species in the form of harm or harassment via directly killing or injuring individual animals, habitat degradation from temporary exposure of occupied features to surface air, and habitat modification due to the disruption of mesocavernous connectivity.

Roadway excavation may directly affect listed karst species due to the removal of 903,459 cubic yards of subsurface limestone in karst zones 1, 2, and 3 (**Table 3-2**). This activity may result in take of listed karst species in the form of harm or harassment via directly killing or injuring individual animals, habitat degradation from temporary exposure of occupied features to surface air, and habitat modification due to the disruption of mesocavernous connectivity.

The installation of drainage culverts, water quality BMPs, and foundations for noise walls may directly affect listed karst species due to the removal of 83,285 cubic yards of subsurface limestone in karst zones 1, 2, and 3 (**Table 3-2**). These actions may result in take of listed karst species in the form of harm or harassment via directly killing or injuring individual animals, habitat degradation from temporary exposure of occupied features to surface air, and habitat modification due to the disruption of mesocavernous connectivity.

The total anticipated volume of subsurface habitat removed as result of the proposed project is 997,844 cubic yards in karst zones 1-3. Half of this volume (51%, 513,357 cubic yards) will be removed from karst zone 1, 20% (194,766 cubic yards) will be removed from karst zone 2, and the remaining 29% (289,721 cubic yards) will be removed from karst zone 3 (**Table 3-2**).

Construction activities for the proposed project may directly affect listed karst species due to the removal of vegetation. This may result in take in the form of harm via habitat degradation resulting from associated fragmentation of trogloxene foraging areas, alterations in nutrient input and outflow, reduction in the carrying capacity of karst habitat, and introduction of invasive species. The proposed project will increase the amount of ROW by 78.8 acres, clear vegetation from an additional 172 acres (103 acres in karst zone 1, 35 acres in karst zone 2, 33 acres in karst zone 3 and 1 acre in karst zone 5).

Direct effects to listed karst species may also occur due to changes in surface and subsurface drainage patterns and changes to subsurface temperature and moisture regimes due to the placement of an additional 98 acres of impervious cover. Because there is no precise mechanism available to calculate the area of surface and subsurface drainage basins of unknown voids that might be affected, it is not possible to quantify the resulting amount or extent of take associated with it.

The removal of an additional 5.10 acres of habitat not surveyed, but unlikely to contain GCWA may result in insignificant and discountable effects to GCWA. Incidental take of GCWA is not anticipated as a result of the proposed project; therefore, indirect and cumulative effects to this species will not be assessed for this species.

3.1.3 Indirect Effects

Indirect effects are caused by the action and occur later in time or farther away from the project footprint but are reasonably certain to occur. Indirect effects for each species are discussed below.

Terrestrial Karst Invertebrates

Changes in the physical environment beneath a newly constructed road create edge effects that extend beyond the construction timeframe, and therefore constitute indirect effects. One of the edge effects is the reduction in water vapor transport into and out of the natural environment caused by the addition of the impervious surfaces of roadways. Natural surfaces, especially those with vegetation, use heat energy for evapotranspiration of water, effectively cooling themselves. Roadways store heat energy, maintaining the surface temperature of the roadway, and raising the temperature and lowering the humidity of the area immediately adjacent to the roadway (Barnes et al. 2012). Roadway materials, such as dark asphalt pavement, are thermally conductive, meaning they have the ability to absorb more heat and rapidly move it into the ground beneath the road surface. Heat stored by roadways is released at night, after the sun has gone down, creating a heat island when compared with surrounding soil or vegetation (Trombulak and Frissell 2000). Roadway heat islands exacerbate subsurface impacts to temperature and moisture by perpetuating drying conditions. While the installation of an additional 98 acres of impervious cover is considered a direct effect to subsurface karst invertebrate habitat, the long-term heat island effect of the additional impervious cover is not possible to quantify.

Indirect impacts caused by future long-term changes in surface and subsurface drainage patterns are expected due to increases or decreases in runoff within the project action area. Changes in the quality of the runoff entering subsurface features resulting from roadway runoff contaminated with increased sediment and hazardous materials from accidental spills and vehicle collisions may also indirectly affect karst invertebrate habitat. Temporary and permanent BMPs such silt fence, rock berms, and detention ponds implemented in accordance with the project's storm water pollution prevention plan (SW3P) and municipal separate storm sewer system (MS4) compliance are intended to mitigate for these impacts both during construction and for the duration of the facility's operation.

3.1.4 Indirect Effects Take Assessment

Indirect effects may result from the long-term changes in surface and subsurface drainage patterns. Construction activities may also indirectly affect listed karst species due to long-term changes in surface and subsurface drainage patterns and long-term changes to temperature and moisture regimes due to heat island effects. Because there is no precise mechanism available to calculate the area of surface and subsurface drainage basins of unknown voids that might be affected, it is not possible to quantify the resulting amount or extent of take associated with it. Given the observed absence of listed karst species during surveys and the existing and continuing urbanization of the US 281 project corridor, the magnitude of potential indirect effects is difficult to ascertain.

3.2 INTERRELATED AND INTERDEPENDENT ACTIONS AND ACTIVITIES

Interrelated actions are those actions that are part of a larger action and depend on the larger action, while interdependent actions are those having no independent utility apart from the proposed action. Although other improvements are under consideration for the US 281 corridor, none of them are dependent on the proposed action for their justification; therefore, there are no effects on listed species from interrelated actions.

Interdependent actions that will result from the construction of the proposed project include the placement of PSLs (e.g. temporary construction offices, staging areas) and the relocation of non-project utilities (e.g. underground water and sewer lines, overhead electrical and communications lines) in the current ROW to outside of the limits of construction. PSLs would likely occur within the current project area and existing ROW and are included in the take assessments in **Section 3.1.2** and **3.1.4** Additional details on access and staging will not be available until the design is finalized and a construction contractor is chosen; however, all PSLs will be located at least 300 feet from any potential listed species habitat unless it has been surveyed in accordance with USFWS protocols to determine that the habitat is not occupied. Therefore, the placement of PSLs will have no effect on listed species. It is not anticipated that non-project utility relocations would occur as a result of this project; however, this is dependent on the final design, which is still in development.

Utilities throughout the corridor will be identified prior to commencement of the main lane construction by a process referred to as Subsurface Utility Engineering (SUE). Only visible surface features were located by surveyors during the schematic development of which overhead electrical and telephone were identified. From Loop 1604 to just south of Marshall Road, the utilities have been relocated under previous projects to the ROW, as it exists today. The proposed corridor from Marshall to the tie-in point at the Cibolo Creek will be much wider and thus, all of the overhead electrical and telephone utility is expected to be adjusted to near the proposed ROW edge. Water and sanitary sewer lines are known to exist along the roadway and will also need to be adjusted. Electrical transmission lines cross over the ROW transversely near the Sonterra Boulevard and are expected to be adjusted due to the direct connector ramp bridge passing over the Sonterra Boulevard overpass. Electrical transmission lines also cross on the north side of Encino Rio, but the elevation of this utility should suffice without needing adjustment.

3.3 CUMULATIVE EFFECTS

Cumulative effects include the effects of future State or private activities not involving Federal activities that are reasonably certain to occur within the action area. Cumulative effects include the impact on the environment which results from the incremental impacts of the proposed project when added to other past, present and reasonably foreseeable future actions. The action area analyzed for potential cumulative effects includes the existing and proposed ROW and an area extending 500 feet outward from the existing and proposed ROW north to the Bexar/Comal County line, which totals 1,530 acres (2.4 square miles).This section presents the identification of other current and reasonably certain future actions to be considered in the cumulative impact analysis of the action area. The focus is on actions or developments that are independent of the proposed action. For this assessment, reasonably certain means actions that are expected to occur within the 2035 timeframe and are likely or probable, rather than merely possible.

3.3.1 Development Predicted by 2035

This section describes past, present, and future land development projected to occur within the action area. No areas of induced growth were identified within the action area. The depiction of past and present (current) development in the action area, shown as gray on **Figure 3-6** is based on 2008 aerial photography with updates from field reconnaissance and information from local experts. Estimates of other reasonably certain future development (shown as green on **Figure 3-6** include (1) areas committed to development (in a darker shade of green), including approved subdivisions and approved Master Development; and (2) other areas considered likely to be subject to development by 2035 if infrastructural improvements *other than the proposed project* are completed (shown in a lighter shade of green). The predicted development data does not represent a footprint of predicted development, but rather the area within which future development is likely to occur. Precise locations and densities would be subject to development conditions and assumptions which cannot be precisely determined at present. Geographical Information Systems (GIS) acreage calculations for past, present, and reasonably foreseeable future development are shown in **Table 3-4.** Acreages are also shown for undevelopable and/or development-constrained areas, like parks, floodplains, and military facilities (shown as orange on **Figure 3-6**).

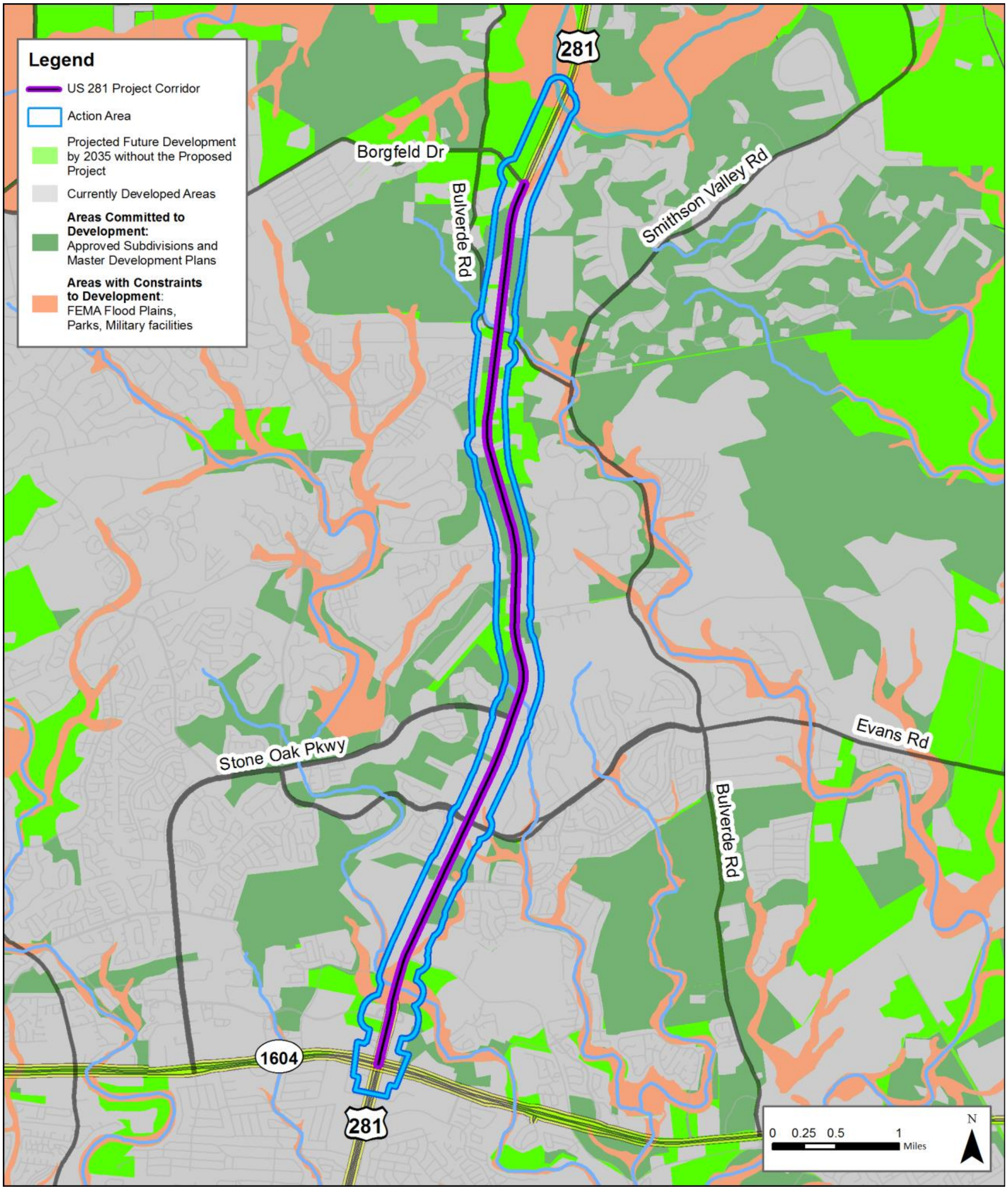
Table 3-4: Development within the Action Area Resulting from Other Past, Present and Reasonably Foreseeable Future Actions by 2035

Area	Acres[1]	% of Action Area
Total Action Area	1,530	-
Current (past/present) development (gray)	876	57%
Other reasonably certain future development unrelated to US 281 project (light green + dark green)	522	34%
Undevelopable and/or constrained areas (orange)	133	9%

Source: US 281 EIS Team 2014 (December).
1 Approximate acreage, rounded to nearest acre

It should be noted that within the action area, there are approximately 876 acres (57 % of the action area) is currently developed, which is not a cumulative impact; however, 522 acres (34 %of the action area) is projected to develop by 2035, with or without the proposed project. The vast majority of predicted development in the action area would be the result private activities not involving Federal activities. This level of increased urbanization would result in substantial future land use change, with accompanying alterations to existing ecological conditions.

Figure 3-6: Current and projected (2035) land development within the action area



Source: US 281 EIS Team, 2014 (December).

3.3.2 Identified Individual Projects

Table 3-5 presents specific past, present, and reasonably certain actions that were identified within the action area that have the potential to substantially influence cumulative land development effects on area resources. This table includes all known projects within State and local transportation plans and projects where any type of consultation was initiated with the USFWS.

Table 3-5: Past, Current and Future Projects

Project Name	Development Entity	Project Description	Construction Year	Effect(s) on Listed Species	Status
US 281 Superstreet Project	Alamo RMA	Superstreet Concept Operational improvements	Constructed 2010	None	Completed
Loop 1604 @ US 281 Interchange Design- Build	Alamo RMA	Construct interchange with non-toll direct connectors	Constructed 2013	May Affect, Not Likely to Adversely Affect, *R. infernalis*, *C. madla*	Completed
Sendero Verde at Hwy 281 (02ETAU00-2013-I-0159)	Unknown	Unknown	Unknown	Unknown	Unknown
US 281 Transit Facility (Park & Ride)	VIA Metro Transit	Site Acquisition (Future Construction of Park & Ride Facility)	2015	Unknown	Unknown
Loop 1604 from FM 1535 to Redland Road	Alamo RMA	Expand to eight lane Expressway, with four new managed lanes and four non-toll lanes	2020	Unknown	Future project – no known consultation plans
Loop 1604 from US 281 to Redland Road	Alamo RMA	Expand to eight lane Expressway, (construct four new managed lanes)	2020	Unknown	Future project – no known consultation plans
US 281 from Stone Oak Parkway to Comal County Line	Alamo RMA	Expand to six lane expressway (construct two additional managed lanes)	2030	Unknown	Future project – no known consultation plans

Source: TxDOT 2010, TxDOT 2014, Alamo Area Metropolitan Planning Organization 2014, US 281 EIS Team 2014.

3.3.3 Cumulative Effects to Endangered Karst Invertebrates

Cumulative effects to listed invertebrate karst species are analyzed with respect to other known actions combined with ongoing development in the action area. Effects may result from additional impervious cover, removal of surface vegetation, increased pollution, modification, and/or destruction of karst features, and alterations to the surface and subsurface hydrological regimes. Development will remove natural vegetative cover; therefore, cave cricket foraging areas will be reduced and subsequently there will be a reduction in the potential carrying capacity of karst invertebrate habitat. Removal of woody surface vegetation may result in a reduction of vegetative root matter penetrating into subterranean voids, a potential point source for the introduction of nutrients into karstic ecosystems. Fragmentation of natural areas may result in a decreased occurrence of trogloxene species (e.g. raccoon, cave crickets) that may dwell in karst features and directly import nutrients from the surface to the subsurface. In addition, development will increase the amount of impervious cover in the area, which would result in increased surface pollution runoff and alterations to surface and subsurface hydrological regimes as water is redirected to man-made drainage systems. These changes may alter the quality and quantity of water entering karst voids. Decreases in water flow or infiltration may result in reduced humidity, slowing the rate of decomposition, while increases in water entering voids may flood habitats, cause drowning of void inhabitants and may wash away nutrients (USFWS 2011a).

Urbanization of undeveloped areas within the action area may also lead to loss of karst invertebrate habitat if voids are filled or collapsed, and unmapped interstitial features are modified. Alteration or destruction of caves reduces overall available habitat and may remove or block movement between karst features. In the context of cumulative effects analysis, concerns about the viability of karst invertebrate populations fall into four categories. The current focus in the San Antonio area is on (1) the designated critical habitat of listed karst species. In addition, there are concerns with (2) listed species potentially occupying known but un-surveyed karst features/caves as well as (3) rare and un-described species occurring in known and/or un-surveyed karst features/caves. Lastly, given the inherently hidden nature of this habitat, there are (4) potential features that can only be discovered when investigated prior to development in the action area.

It should also be noted that areas for which ROE was not granted at the time of survey were not investigated; therefore, determinations regarding karst invertebrate species within these areas cannot be made at this time. In the face of these uncertain scenarios, it is worth restating that: (1) no occupied endangered karst invertebrate habitat was discovered in the surveys completed in the fall of 2010 within a 500-foot buffer from the proposed project ROW (see **Section 2.4.1**); (2) the majority of the action area (876 acres, 57 %) is currently developed; therefore impacts to karst species may have already occurred in these areas, and (3) approximately 522 acres (34 %) of the action area and has been identified as subject reasonably foreseeable future development by 2035 that will occur with or without the proposed project.

To attempt to quantify cumulative effects to terrestrial karst invertebrates and their habitat, the estimates of existing and reasonable foreseeable future development within the action area discussed in **Section 3.3.1** and shown in **Figure 3-6** was assessed using a GIS to overlay and quantify these areas by karst zone (**Table 3-6)**. Areas mapped as karst zones 1, 2, and 3 account for 1,493 acres or 98% of the 1,530 acre action area. No areas of karst zone 4 occur within the action area and areas mapped as karst zone 5 are areas where karst invertebrates are unlikely to occur; therefore, zones 4 and 5 were not included in this assessment. Of the 1,493 acres in karst zones 1, 2, and 3 in the action area, 57% is developed, 34% is reasonably certain to develop in the future, and 8% is protected from development or not developable due to its location in a park, preserve, or floodplain. No areas of induced growth are located within the action area or within karst zones. The development quantified in **Table 3-6** is reasonably certain to occur with or without the proposed project and is likely to result in adverse effects to listed karst invertebrates where development intersects occupied karst habitat.

Table 3-6: Predicted Development by 2035 within the Action Area resulting from Other Past, Present, and Reasonably Certain Future Actions by Karst Zone.

Area	Karst Zone 1	Karst Zone 2	Karst Zone 3	Karst Zone 5	Total Acres in Karst Zones[1]
Total Action Area	749	453	291	19	1512
Current (past/present) development (gray)	467	286	123	0	876
Other reasonably certain future development unrelated to US 281 project (light green + dark green)	272	104	143	0	519
Undevelopable and/or constrained areas (orange)	10	63	25	19	116

Source: US 281 EIS Team, 2014 (December).
1 Approximate acreage, rounded to nearest acre

3.4 ANALYSIS OF ADVERSE MODIFICATION TO CRITICAL HABITAT

Critical habitat is defined as a geographic area(s) that contains features essential for the conservation of a threatened or endangered species and that may require special management and protection. Destruction or adverse modification of critical habitat refers to direct or indirect alterations that appreciably diminish the conservation value, or recovery potential, of critical habitat for listed species (USFWS 2014d). The USFWS identified several PCEs that are essential to the conservation of karst invertebrates during the designation of critical habitat including:

1) "Karst-forming rock containing subterranean spaces (caves and connected mesocaverns) with stable temperatures, high humidities (near saturation), and suitable substrates (for example, spaces between and underneath rocks for foraging and sheltering) that are free of contaminants and
2) Surface and subsurface sources (such as plants and their roots, fruits, and leaves, and animal (e.g., cave cricket) eggs, feces, and carcasses) that provide nutrient input into the karst ecosystem" (USFWS 2012, p. 8464).

When delineating CHU boundaries for the Bexar County karst invertebrates in 2012, the USFWS used the following criteria:

1) All areas known to be occupied by the species;
2) Cave footprint with the surface and subsurface drainage areas of the cave, where known;
3) Cave cricket foraging area that is a 105 meter (344-foot) circle around the cave entrance;
4) An area of at least 100 acres around the cave footprint of undisturbed or restorable vegetation as recommended by the Bexar County Karst Invertebrates Recovery Team; and
5) Specified goals including maintaining high humidity, stable temperatures, high water quality of surface and subsurface drainage basins, and good connectivity with mesocaverns for population dynamics of troglobites (USFWS 2012).

The Bexar County Karst Invertebrates Recovery Plan (USFWS 2011a) uses Karst Faunal Areas (KFAs) and KFRs to determine the recovery standard for each karst species and determined that *R. exilis*, the only species known to occur in CHU 12 at the time of designation, requires one high and two medium KFAs established within each KFR to achieve the recovery standard for the species. High quality KFAs must be at least 100 ac and medium quality KFAs 40 to 99 ac, and they must include the entire surface and subsurface drainage basins of cave and karst features, native surface plant and animal communities, and cave and karst footprints over 328 feet from the unit's edge (USFWS 2011a).

CHU 12 is characterized by low-quality habitat due to heavy urbanization and quarrying within its boundaries. The existing conditions within and surrounding CHU 12 are discussed in **Section 2.3.1** The CHU 12 boundaries extend a maximum of 11 feet into the ROW for a distance of 180 feet, totaling 0.023 acres along the eastern boundary of the unit. The 0.023 acres of CHU 12 within the existing US 281 ROW consists of sparse, unmaintained woody vegetation and grasses on limestone bedrock, separated from the remainder of the CHU by a concrete block fence (**Figure 2-9**). Areas of undisturbed, native vegetation and associated surface wildlife, both of which are considered to be PCEs for karst species habitat, are also sparse within the remainder of CHU 12. The surface and subsurface drainage basins of Hairy Tooth and Ragin' Cajun Caves have not been delineated; however, the entrances to these caves are at a higher elevation than the 281 ROW and their surface drainage basins do not extend into the ROW. Much of their surface drainage basins (another PCE) have been modified through urbanization and will not be further impacted by the proposed project.

3.4.1 Quantification of Subsurface Impacts to CHU 12

While subsurface impacts within karst zones 1, 2, and 3 were described in **Section 3.1.1** for the entire proposed project, approximately 96 cubic yards of subsurface limestone removal will occur in the area where CHU 12 extends into the ROW (**Table 3-7**). The station ranges described below correspond with Preliminary Schematic Drawings of the proposed project found in **Appendix A.** These descriptions are provided to better understand the proposed subsurface impacts relative to existing conditions.

CHU-12 enters the ROW at about station 415 end exits near station 420 (**Appendix A – Sheet 3**). The maximum penetration onto the existing ROW is approximately fifteen feet at station 418. No excavation is planned for this area with the exception of foundations for a noise wall between the ROW and the Big Spring subdivision that could be located nearer the south bound frontage road outside of the CHU-12 habitat. The foundation design has not been determined at this time; however, thirty-six inch drilled shafts on eight foot centers at approximately twenty feet deep could be required.

Table 3-7: Proposed subsurface limestone removal by karst zone and by construction activity within CHU 12

Construction Activity	Karst Zone 1		
	Station Range[1] 415+00 to 420+00		
	Excavation	Downward Cut	
	cubic yards	Min (ft)	Max (ft)
Geotechnical Borings	0	-	0
Bridge Foundation Drilled Shafts	0	-	0
Roadway Excavation	0	0	0
Drainage Culverts	0	0	0
Water Quality BMP	0	0	0
Cantilevered Noise Wall Foundations	96	0	12
Total	96		

1: Station Ranges correspond to Preliminary Schematic Drawings of the proposed project found in Appendix A

Removal of vegetation associated with installation of a southbound frontage within the ROW will have no effect on cricket foraging around Ragin' Cajun Cave, since it is 1,160 feet away, well beyond the 345 feet cricket foraging radius accepted by USFWS. Indirect disturbance to CHU 12 may include increased noise and light levels and vibration from construction equipment, which may influence the diurnal movement patterns of small mammals and discourage cave crickets or other trogloxenes from exiting the caves. The intensity of this potential disturbance would be low, temporary, and concentrated along the 0.023 acres of the CHU that extends into the ROW.

Surface drainage from the proposed project ROW in the vicinity of CHU 12 flows to the east, away from the CHU. Although surface drainage basins for Hairy Tooth Cave and Ragin' Cajun Cave have not yet been delineated, the cave entrances are higher in elevation than the ROW and would not extend into the ROW. Since the ROW does not intersect the surface drainage basins of Hairy Tooth Cave or Ragin' Cajun Cave, no effects on CHU 12 from alteration of surface drainage related to US 281 are anticipated. The subsurface drainage basins for Hairy Tooth Cave and Ragin' Cajun Cave have not been delineated. The deepest mapped elevation of Hairy Tooth Cave is entirely up gradient of the proposed project grade; therefore, the project will have no impacts to the subsurface drainage basin of known portions of the cave. The difference between the proposed project grade and the base of Ragin' Cajun Cave represents a slope of approximately 5 degrees. Known caves in the US 281 corridor tend to descend much more steeply and it is unlikely that water entering the subsurface as a result of the down-cutting of grade at US 281 would maintain a shallow enough descent to reach the lowest known point in Ragin' Cajun Cave. Any effects from down-cutting of grade along the southeastern edge of CHU 12 would be limited to the edge area.

The proposed project will impact 0.023 acres of CHU 12 that extend into the ROW by removal of vegetation; however, these impacts will have no effect on Hairy Tooth or Ragin' Cajun caves, and will not appreciably diminish the value of the critical habitat for the survival and recovery of the species within CHU 12 due to the location of these caves at 1,570 and 1,160 feet from the ROW, respectively (**Figure 2-8**). There will be no construction activities conducted beyond the ROW due to the existing Big Spring subdivision; therefore, there will be no impacts to the trogloxene foraging areas, alterations in nutrient input and outflow, or long-term changes in surface drainage patterns of Hairy Tooth or Ragin' Cajun Caves. The proposed activities in the vicinity of CHU 12 will not significantly diminish any of the PCEs contributing to the survival and recovery of *R. exilis*.

3.5 CONSERVATION MEASURES

3.5.1 Measures to be Implemented During Project Design

The proposed construction footprint would minimize impacts to CHU 12 and to native vegetation, especially woodland impacts. The portion of CHU 12 that touches the proposed ROW is a built out subdivision, and project designers sought to avoid impacting both CHU 12 and the residential neighborhood to the maximum extent possible. Appropriate BMPs to minimize construction phase erosion and sedimentation impacts would be incorporated into the proposed project and related notes and diagrams would be included in required TCEQ permitting documents such as the SW3P, Water Pollution Abatement Plan (WPAP), and construction plans. The SW3P and WPAP will be prepared during the final design stages of the project.

3.5.2 Measures to be Implemented During Project Construction

Federally Listed Species

Terrestrial Karst Species

Void Discovery Oversight and Reporting

It is possible that other potential karst features or caves may be revealed during any excavation below the current grade or further into existing road cuts during the proposed project. The contractor will supply a licensed Professional Geoscientist (PG) as required by Edwards Aquifer Rules. If voids are encountered during construction, the PG will perform an initial assessment (through step 3 of USFWS [2014] karst invertebrate survey protocols [p. 4]). If the PG determines that the feature provides potential habitat for listed karst invertebrate species, a karst biologist holding an appropriate Section 10(a)1(A) permit will inspect the feature to determine its scientific or conservation value. The surface expression of the void will be covered between the time the void is opened and the time that a karst biologist is available to inspect it, in order to minimize the influence of diurnal variations in surface temperature and to retain moisture. Hazard fencing or barricades may be used to protect the area if there is a fall hazard, such as the case of an open shaft. Appropriate BMPs, including the installation of silt fencing and/or silt socks and immediate area work stoppage, will be implemented to minimize surface runoff from entering the feature. This is intended as an avoidance and minimization measure for *C. madla* and both *Rhadine* species.

Monitoring Reports

Project reports will be prepared monthly to document the number and location of voids encountered and at what depth, a summary of the results of any karst invertebrate survey conducted, any observations made with a down-hole camera, a summary of the work actions completed during the reporting period, and what actions are anticipated in the next reporting period.

Project Specific Locations

All PSLs, such as staging areas, will be located at least 300 feet from any known listed species location or potential habitat. TxDOT will provide an information packet to project contractors, including information on karst species habitat that may occur outside of the ROW and requirements to avoid effects to the karst species or their habitat.

Water Quality

The proposed project has the potential to impact groundwater quality via contamination of metals and organic compounds, accidental spills from storage tanks on vehicles, petroleum fuels, and hazardous materials. The potential for groundwater contamination is increased due to the numerous karst features surrounding the project corridor. Karst features can act as a conduit for rapid transmission of contaminants into groundwater.

Under the guidance of the Edwards Aquifer Protection Program, groundwater quality mitigation practices include defining the extent of contamination plumes, predicting groundwater flow paths, building and maintaining effective monitoring networks, and treating contaminated water. Temporary BMPs used during construction may include silt fencing, inlet protection, soil retention blankets, rock check dams, sedimentation ponds, mulch socks, and seeding. Permanent water quality treatments may include vegetated filter strips and bio-retention. These water-quality control structures are part of the BMPs put in place to help offset potential impacts through short-term retention or filtration prior to discharging to streams. The proposed project has unpaved and informal shoulders along the entire corridor from Loop 1604 to Borgfeld Drive, and does not have a storm water drainage system that meets current TCEQ WPAP standards except in the vicinity of newly constructed US 281 Super Street sections. As such, the US 281 project corridor would remain susceptible to contaminants.

The TCEQ Edwards Aquifer Rules for development within the Contributing and Recharge Zones of the Edwards Aquifer require the use of temporary and permanent BMPs that treat storm water runoff from impervious cover. The regulations require the removal of 80 percent of total suspended solids (TSS) in storm water runoff from the increase in impervious cover resulting from the project. The proposed project will exceed this requirement to meet 80 percent TSS removal for the project as a whole, by meeting the 80 percent TSS removal threshold at each storm water outfall. Typically for a project of this scale the water quality treatment, or TSS removal, would occur sporadically throughout the project at concentrated sites to minimize the number of BMPs necessary to reduce the pollutant load released offsite to an acceptable level, 80 percent removal overall. This would reduce construction costs and would meet the minimum requirements of the TCEQ guidelines, yet some of the storm runoff would get released untreated. A project could over-treat some storm runoff at some locations yet let a fraction get conveyed downstream untreated. The US 281 Corridor Project will remove a minimum of 80 percent of TSS at each storm water outfall, therefore will not let any storm water runoff leave the project without first passing through a temporary (during construction) or permanent BMP (post construction) to remove the necessary pollutant load. The TSS calculations for the proposed project are included in **Appendix E**.

Generally the most contaminated storm water runoff occurs during the first pulse of runoff generated during a storm event, which mobilizes particles and contaminants that have accumulated on impervious surfaces since the previous rainfall event. The design plans for the proposed project call for the installation of temporary and permanent storm water BMPs that would capture and treat the first pulse according to TCEQ guidelines. The current highway design, as it exists today on the ground, does not include any storm water BMPs for treating TSS and other contaminants, except at the newly constructed US 281 Super Streets project area; therefore, the proposed project would result in an increase in contaminant removal.

With the implementation of TCEQ-approved storm water BMPs, quality of highway runoff water would be improved. Improvements in runoff water quality could result in improved groundwater quality, because highway runoff is not currently treated before entering streams or karst features that may recharge the Edwards Aquifer. The intended result would be an improvement in the quality of surface water and groundwater associated with the project corridor. These measures will help to avoid and minimize take of listed karst invertebrate species that may be otherwise exposed to contaminants entering the karst features through groundwater infiltration.

Golden-cheeked Warbler

To avoid/minimize any potential impacts to the GCWA, the following guidelines would be followed during construction:

- Limiting the removal of woody vegetation to outside of the breeding and nesting season, which lasts from March 1 to September 1
- Limiting removal of vegetation to that necessary for constructing the US 281 Corridor Project
- Locating construction staging areas away from potential GCWA habitat

Post-project Site Restoration

All disturbed areas will be re-vegetated according to TxDOT's standard practices for urban areas and the TCEQ Construction General Permit (CGP) to the extent practicable, in compliance with Executive Order 13112 on Invasive Species and the Executive Memorandum on Beneficial Landscaping. Re-vegetation efforts would provide appropriate and sustainable cover to prevent erosion and siltation.

3.5.3 Range-wide Conservation Measures

On-going *Cicurina* Genetics Study

An ongoing study into the genetics and distribution of *Cicurina* spiders in Bexar and adjacent counties provides exceptional conservation value across the range of all listed *Cicurina* species. This measure enhances the survival and recovery of *C. madla* by focusing taxonomic resolution of eyeless *Cicurina* at known and suspected *C. madla* locations throughout the range.

On-going Cave Biota Surveys

An ongoing study into the fauna assemblages of caves in Bexar and adjacent counties provides exceptional conservation value for *Cicurina* and *Rhadine* species. This measure enhances the survival and recovery of both genera by providing information on species distribution throughout their range.

Revise Karst Zone and Karst Fauna Region Maps

Re-assess the current boundaries of the karst zone and karst fauna region maps using the most up to date distribution information available. These maps are heavily utilized by researchers and others making regulatory decisions and determining the level of rigor required for ESA compliance. This measure benefits *Cicurina* and *Rhadine* throughout their range.

Provide Educational Opportunities

TxDOT will partner with TPWD or another suitable local entity to develop or enhance already existing educational opportunities for local school children, such as field trips or classroom materials. This measure is applicable to *Cicurina* and *Rhadine* species.

Provide Professional Development Opportunities

TxDOT will seek out partnership with a local professional organization, such as the Edwards Aquifer Authority, to support a total of three professional training sessions. This measure is applicable to *Cicurina* and *Rhadine* species.

Cave and CHU Specific Conservation Measures

Enhance Protection for Genesis Cave

Investigate mechanisms for updating and enhancing protection measures for Genesis Cave, which may include improved fencing, gating, and/or educational signage.

Biota surveys to establish species status within caves in Stone Oak Park (CHU 21)

Critical Habitat Unit 21, Stone Oak Park, consists of 154 acres of private and City of San Antonio-owned land in northeastern Bexar County (USFWS 2012). This unit contains three *R. exilis* occupied caves: Hornet's Last Laugh Pit, Kick Start Cave, and Springtail Crevice, and may contain other caves containing the species. The unit was delineated by drawing a 100 acre circle around each of the three caves and joining the edges of the three overlapping circles. The cave footprints and drainage basins for these caves have not been delineated. CHU 21 is considered to be the most promising site within the Stone Oak KFR for establishing a Karst Fauna Area, an essential step toward recovery for *R. exilis*.

Conservation measures for *R. exilis* within CHU 21 include the following:

- TxDOT will work with the City of San Antonio Parks and Recreation Department to survey, map and protect the caves within Stone Oak Park, to include Bear Cave, Cub Cave, and the Springtail cave cluster.

- During the construction phase of the proposed project, TxDOT will offer to develop and implement a management plan, and/or provide equipment and training for San Antonio Parks and Recreation Department staff to perform control measures for *Solenopsis invicta.*

Map Subsurface Drainage Basin of Caves Located in CHU 12

The subsurface drainage basins of Hairy Tooth Cave and Ragin' Cajun Cave will be delineated. The subsurface drainage basin defines the catchment area where recharging water ultimately reaches the cave via pore spaces in the soil and rock and subsurface conduits. Cave maps will reflect locations of important features such as speleothems, fractures, and points where water enters or exits the caves. Additional information such as observed fracture and/or fault orientations, hydrologic features in bedrock (scallops, fluting, rills, cupolas, domes, etc.), secondary mineral precipitants (stalagmites, stalactites, flowstone, etc.), lithologic properties and location, and type and orientation of surface karst features will also be included in this evaluation to determine the likely flowpaths of water to the cave through the subsurface. All measurements of feature orientations will be measured in degrees from true north.

Chapter 4

Effect Determinations

4.1 MAY AFFECT, NOT LIKELY TO ADVERSELY AFFECT DETERMINATIONS FOR LISTED SPECIES

The US 281 Corridor Project described within this BA ***may affect, but is not likely to adversely affect***, the GCWA for the following reasons:

- A 2009 habitat assessment identified potential habitat for this species within the project area. Since the construction of the proposed project would remove 44.74 acres of potential habitat, appropriate steps were taken to determine whether the project could directly affect the GCWA.
- After three seasons of survey effort following appropriate USFWS protocol, no GCWA were detected and habitat quantity and quality losses continued due to development impacts and both man-induced and natural woodland losses in the corridor.
- Nesting deterrents for the GCWA are common and likely increasing due to urbanization, noise, and the prevalence of typical nest predator and social parasite species such as the Western Scrub Jay, Great-tailed Grackle, and Brown-headed Cowbird. Given the negative survey findings and increasing downward spiral of habitat quality, it does not seem likely that the GCWA would utilize the project corridor.
- Given the negative survey findings to date and decline of habitat quality, it is not likely that the GCWA will be directly affected by the removal of 39.64 acres of potential GCWA habitat known to be unoccupied. The removal of an additional 5.10 acres of habitat not surveyed, but unlikely to contain GCWA may result in insignificant and discountable effects to GCWA.

4.2 MAY AFFECT, LIKELY TO ADVERSELY AFFECT DETERMINATIONS FOR LISTED SPECIES

The US 281 Corridor Project described within this BA ***may affect, and is likely to adversely affect*** *R. exilis* and *R infernalis* for the following reasons:

- The project area is only 1.7 miles east of the known range of *R. infernalis*, and within the range of *R. exilis*.
- The proposed project is expected to disturb or remove approximately 997,844 cubic yards of subsurface limestone or karst invertebrate habitat which may result in take of listed karst species in the form of harm or harassment via directly killing or injuring individual animals, habitat degradation, and habitat modification. Additionally, the proposed project is expected to impact

up to 172 acres of vegetation, add approximately 98 acres of impervious cover, both of which may result in take of listed karst species in the form of harm via habitat degradation.

- While *Rhadine* beetles appear to favor caves with natural sinkhole entrances rather than entranceless voids, they may still exist there; therefore, adverse effects on habitat for these species cannot be considered insignificant or discountable.

TxDOT requests incidental take coverage for any *R. exilis and R. infernalis* encountered throughout the proposed project area for the entire duration of the construction activities.

The proposed project described within this BA ***may affect, and is likely to adversely affect*** *C. madla* for the following reasons:

- Although the project area lies 7 miles to the east of the currently understood range for this species, *C. madla* is known from the Stone Oak KFR, meaning there are no geologic or physical barriers to the species distribution as far as the project area. Analysis of subterranean fauna detected in accidentally opened voids shows that *Cicurina* species are likely to inhabit them. Based on current knowledge of *Cicurina* distribution in the project area, it is more likely that any *Cicurina* specimens encountered would represent *C. bullis, C. platypus,* or *C. puentecilla*; however, given the nature of mesocavernous connectivity and the presence of *C. madla* within the Stone Oak KFR, potential adverse effects on this species cannot be considered insignificant or discountable. While species surveys conducted for this project did not detect the species, immature specimens of eyeless *Cicurina* that were collected could not be definitively identified via morphological characteristics.

- Implementation of the proposed improvements could also indirectly affect the surrounding karst ecosystem where karst species might occur. Potential indirect effects from altered surface drainage patterns, increased impervious cover, and increased temperature and lower humidity caused by roadway heat islands effects may result in short and long-term changes to previously stable temperature and moisture regimes in nearby subsurface habitat. The destruction of minor void spaces in the interchange area could possibly change mesocavernous connectivity in the subsurface.

- The proposed project is expected to disturb or remove approximately 997,844 cubic yards of subsurface limestone or karst invertebrate habitat which may result in take of listed karst species in the form of harm or harassment via directly killing or injuring individual animals, habitat degradation, and habitat modification. Additionally, the proposed project is expected to impact up to 172 acres of vegetation, add approximately 98 acres of impervious cover, both of which may result in take of listed karst species in the form of harm via habitat degradation. Potential adverse effects to karst species are offset by TxDOT's proposed temporary and permanent BMPs such as diversion of runoff, silt fencing, rock berms, and detention ponds which will reduce the potential to adversely impact karst habitat near the project area. Additionally, there are expected beneficial effects to endangered karst species from the proposed voluntary conservation measures indicated in **Section 3.5.3**

TxDOT requests incidental take coverage for any *C. madla* encountered throughout the proposed project area for the entire duration of the construction activities.

4.3 ADVERSE MODIFICATION TO CRITICAL HABITAT

The proposed project is not anticipated to result in adverse modification to critical habitat designated for *R. exilis* in CHU 12. The primary constituent elements that exist in CHU 12 will not be degraded as a result of the proposed project because no impacts to the current quality or quantity of the cricket foraging area, or impacts to the surface or subsurface drainage basins will occur

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Chapter 5
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———. 2012d. Karst invertebrate technical report for north wall voids 31, 32, 33, & 34 at Loop 1604, Bexar County, Texas. Prepared for Hicks & Company, 9 April 2012. 23 pp.

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Appendix A

Preliminary Schematic Drawings of the Preferred Expressway Alternative

INTERIM REVIEW

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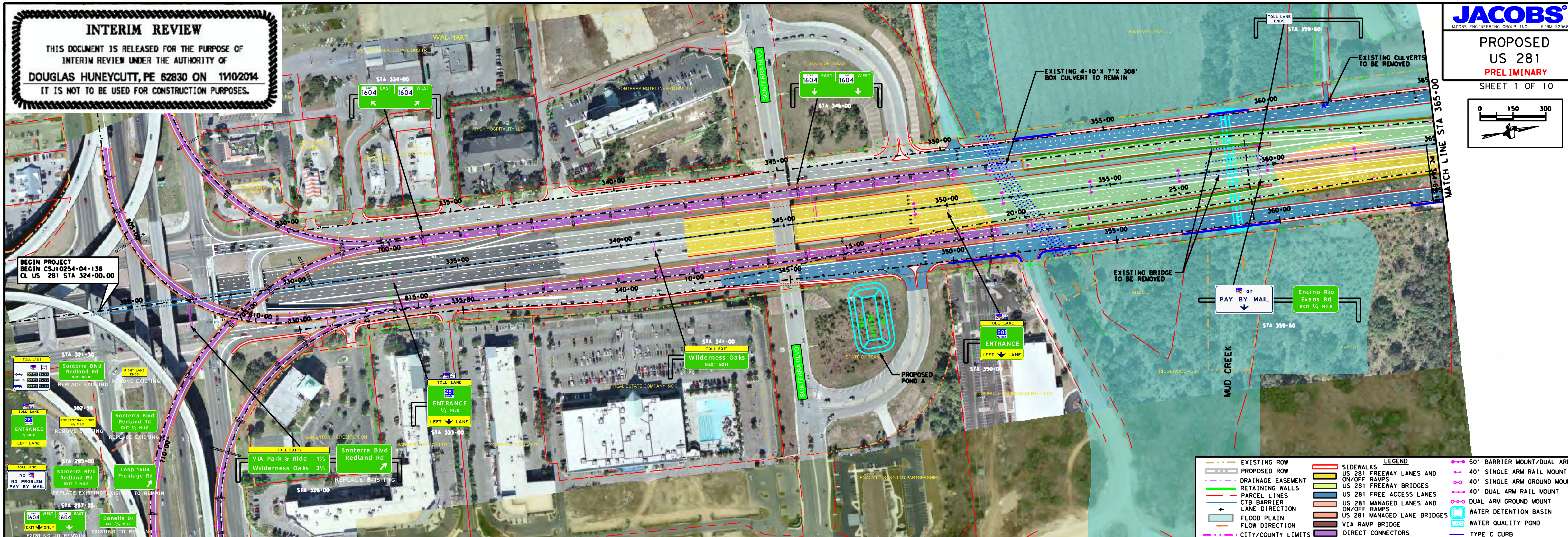
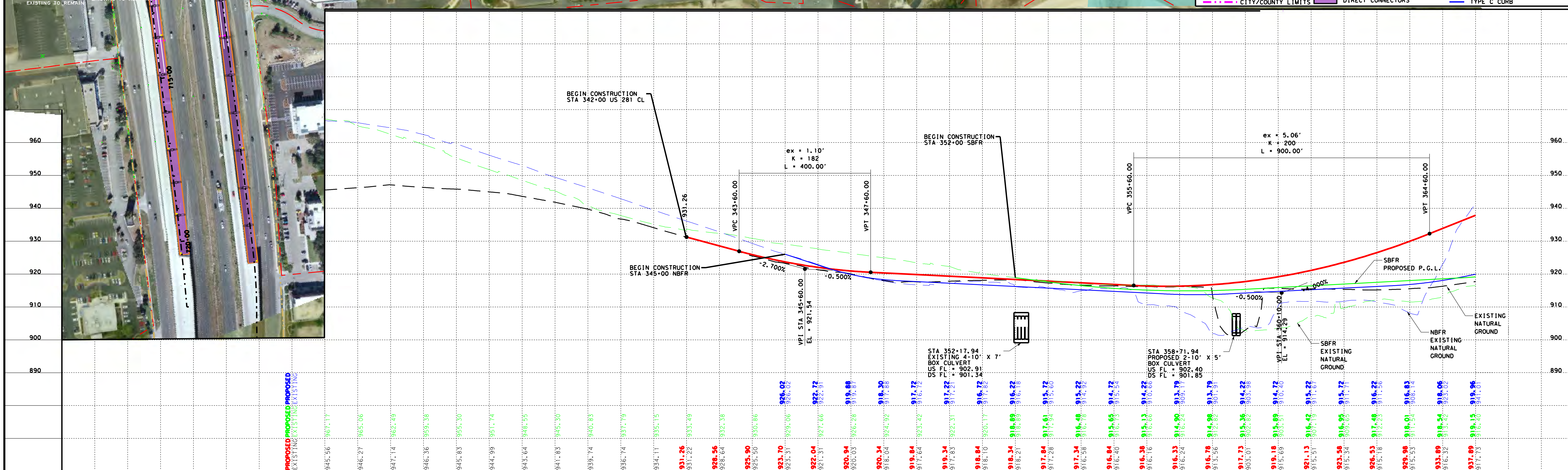
PROPOSED
US 281
PRELIMINARY

SHEET 1 OF 10



LEGEND

EXISTING ROW
PROPOSED ROW
DRAINAGE EASEMENT
RETAINING WALLS
PARCEL LINES
CTB BARRIER
LANE DIRECTION
FLOOD PLAIN
FLOW DIRECTION
CITY/COUNTY LIMITS
SIDEWALKS
US 281 FREEWAY LANES AND ON/OFF RAMPS
US 281 FREEWAY BRIDGES
US 281 FREE ACCESS LANES
US 281 MANAGED LANES AND ON/OFF RAMPS
US 281 MANAGED LANE BRIDGES
VIA RAMP BRIDGE
DIRECT CONNECTORS
50' BARRIER MOUNT/DUAL ARM
40' SINGLE ARM RAIL MOUNT
40' SINGLE ARM GROUND MOUNT
40' DUAL ARM RAIL MOUNT
DUAL ARM GROUND MOUNT
WATER DETENTION BASIN
WATER QUALITY POND
TYPE C CURB



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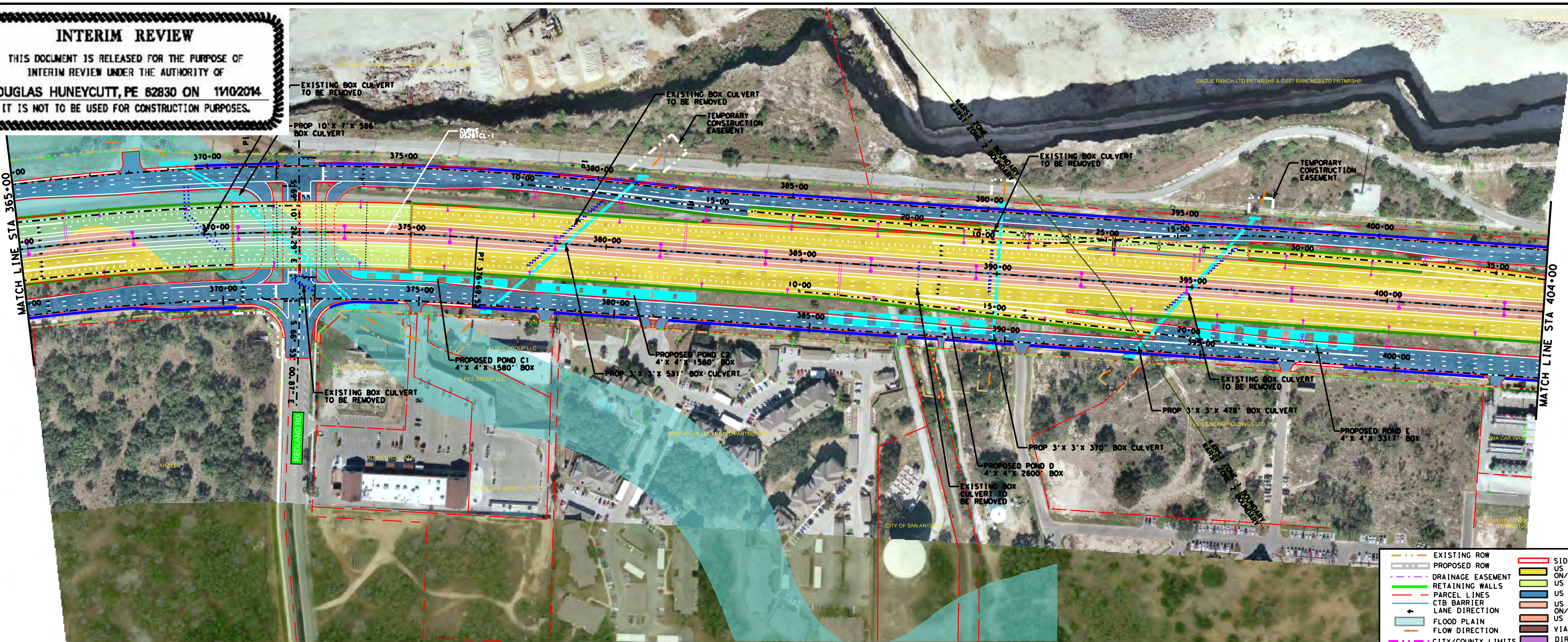
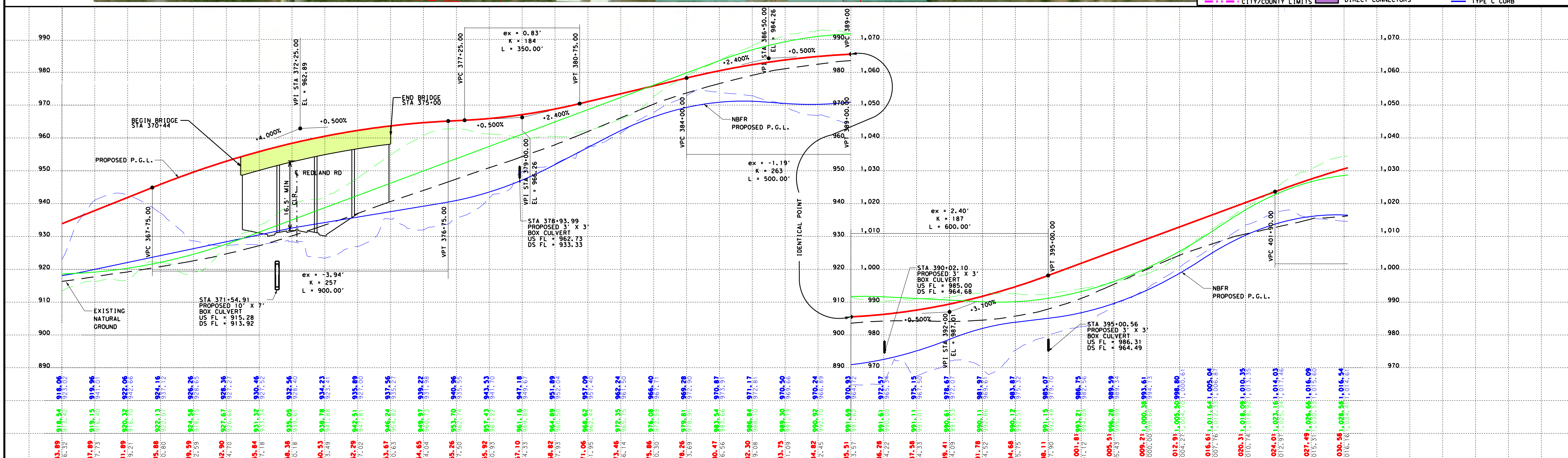


LEGEND

EXISTING ROW	SIDEWALKS
PROPOSED ROW	US 281 FREEWAY LANES AND ON/OFF RAMPS
DRAINAGE EASEMENT	US 281 FREEWAY BRIDGES
RETAINING WALLS	US 281 FREE ACCESS LANES
PARCEL LINES	US 281 MANAGED LANES AND ON/OFF RAMPS
CTB BARRIER	US 281 MANAGED LANE BRIDGES
LANE DIRECTION	VIA RAMP BRIDGE
FLOOD PLAIN	DIRECT CONNECTORS
FLOW DIRECTION	
CITY/COUNTY LIMITS	

50' BARRIER MOUNT/DUAL ARM
40' SINGLE ARM RAIL MOUNT
40' SINGLE ARM GROUND MOUNT
40' DUAL ARM RAIL MOUNT
DUAL ARM GROUND MOUNT
WATER DETENTION BASIN
WATER QUALITY POND
TYPE C CURB



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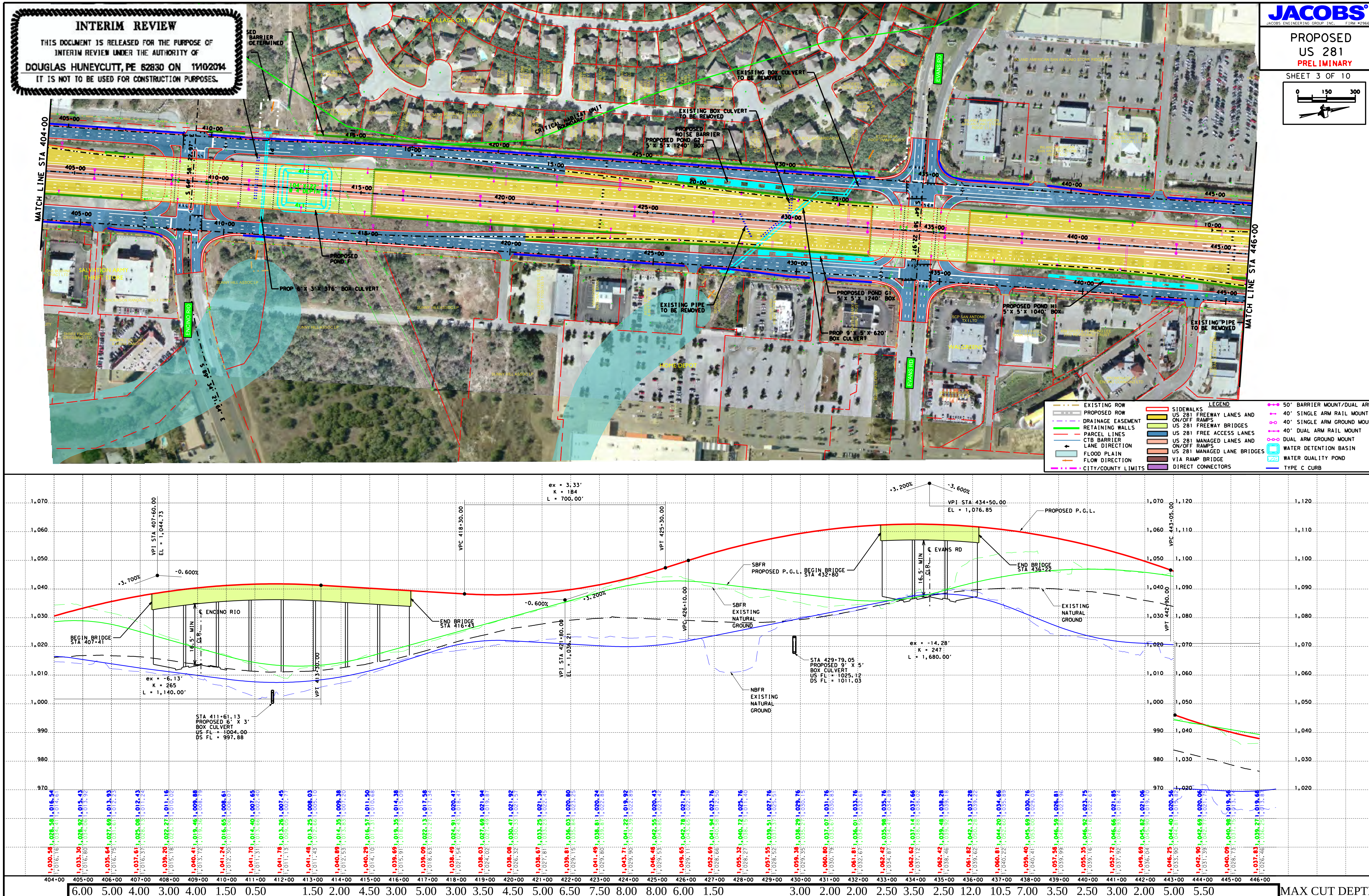

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JACOBS
JACOBS ENGINEERING GROUP INC. FIRM #2966
PROPOSED
US 281
PRELIMINARY
SHEET 3 OF 10
0 150 300
MATCH LINE STA 404+00
MATCH LINE STA 446+00
LEGEND
EXISTING ROW
PROPOSED ROW
DRAINAGE EASEMENT
RETAINING WALLS
PARCEL LINES
CTB BARRIER
LANE DIRECTION
FLOOD PLAIN
FLOW DIRECTION
CITY/COUNTY LIMITS
SIDEWALKS
US 281 FREEWAY LANES AND ON/OFF RAMPS
US 281 FREEWAY BRIDGES
US 281 FREE ACCESS LANES
US 281 MANAGED LANES AND ON/OFF RAMPS
US 281 MANAGED LANE BRIDGES
VIA RAMP BRIDGE
DIRECT CONNECTORS
50' BARRIER MOUNT/DUAL ARM
40' SINGLE ARM RAIL MOUNT
40' SINGLE ARM GROUND MOUNT
40' DUAL ARM RAIL MOUNT
DUAL ARM GROUND MOUNT
WATER DETENTION BASIN
WATER QUALITY POND
TYPE C CURB
EXISTING BOX CULVERT TO BE REMOVED
PROPOSED NOISE BARRIER
PROPOSED POND G2 5' X 5' X 1240' BOX
CRITICAL HABITAT LIMIT
PROPOSED POND F
PROP 6' X 3' X 376' BOX CULVERT
EXISTING PIPE TO BE REMOVED
PROPOSED POND G1 5' X 5' X 1240' BOX
PROP 9' X 5' X 620' BOX CULVERT
PROPOSED POND H1 5' X 5' X 1040' BOX
ENCINO RIO
EVANS RD
SALVATION ARMY THRIFT STORE
HOME DEPOT
WALGREENS
VPI STA 407+60.00 EL = 1,044.73
+3.700%
-0.600%
ex = 6.13' K = 265 L = 1,140.00'
BEGIN BRIDGE STA 407+41
℄ ENCINO RIO
16.5' MIN CLR.
END BRIDGE STA 416+43
STA 411+61.13 PROPOSED 6' X 3' BOX CULVERT US FL = 1004.00 DS FL = 997.88
ex = 3.33' K = 184 L = 700.00'
VPC 418+30.00
VPT 425+30.00
VPI STA 421+80.00 EL = 1,036.21
-0.600%
+3.200%
VPC 426+10.00
SBFR PROPOSED P.G.L.
SBFR EXISTING NATURAL GROUND
NBFR EXISTING NATURAL GROUND
STA 429+79.05 PROPOSED 9' X 5' BOX CULVERT US FL = 1025.12 DS FL = 1011.03
+3.200%
-3.600%
VPI STA 434+50.00 EL = 1,076.85
BEGIN BRIDGE STA 432+80
℄ EVANS RD
16.5' MIN CLR.
END BRIDGE STA 436+22
ex = 14.28' K = 247 L = 1,680.00'
PROPOSED P.G.L.
EXISTING NATURAL GROUND
VPC 443+05.00
VPT 442+90.00
6.00 5.00 4.00 3.00 4.00 1.50 0.50 1.50 2.00 4.50 3.00 5.00 3.00 3.50 4.50 5.00 6.50 7.50 8.00 8.00 6.00 1.50 3.00 2.00 2.00 2.50 3.50 2.50 12.0 10.5 7.00 3.50 2.50 3.00 2.00 5.00 5.50
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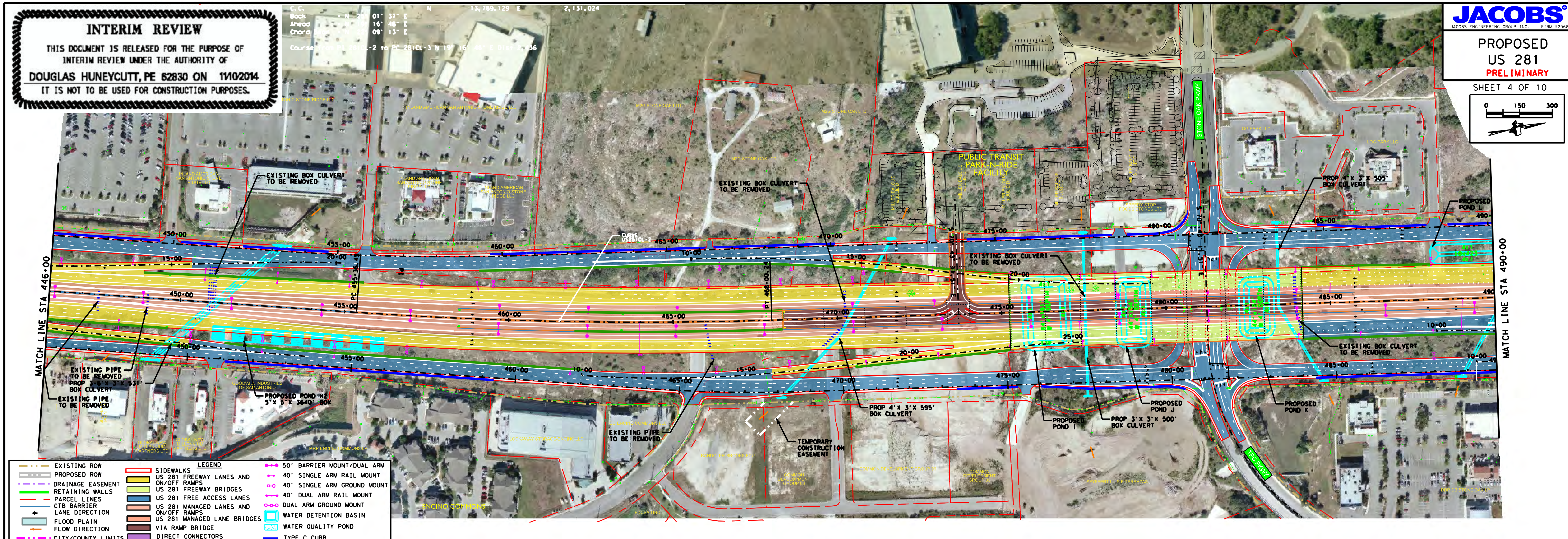

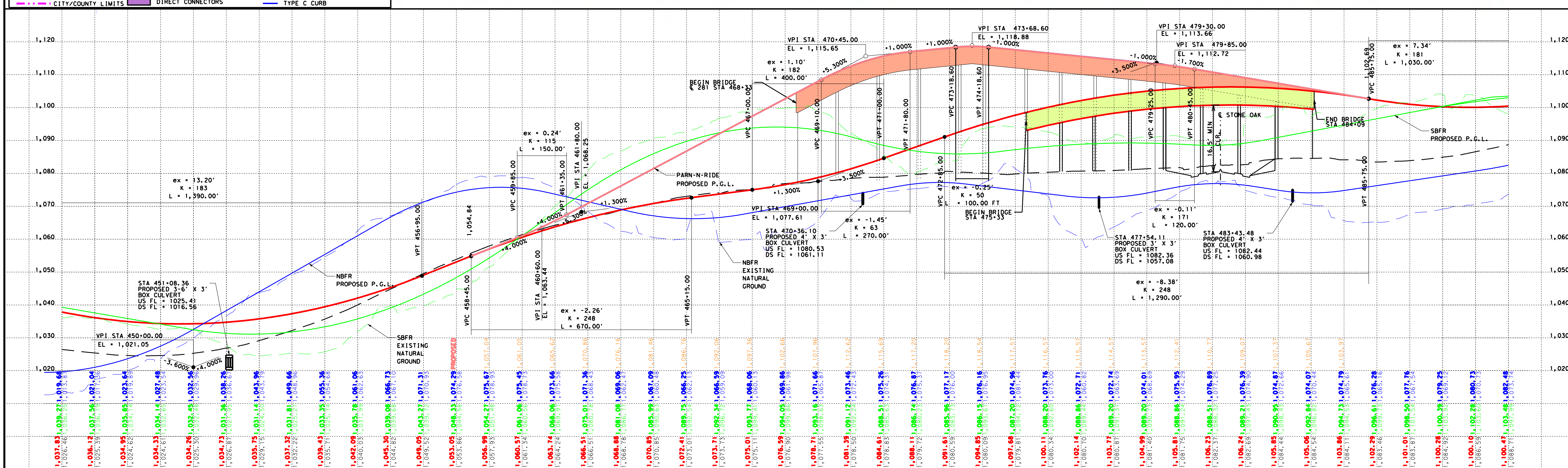

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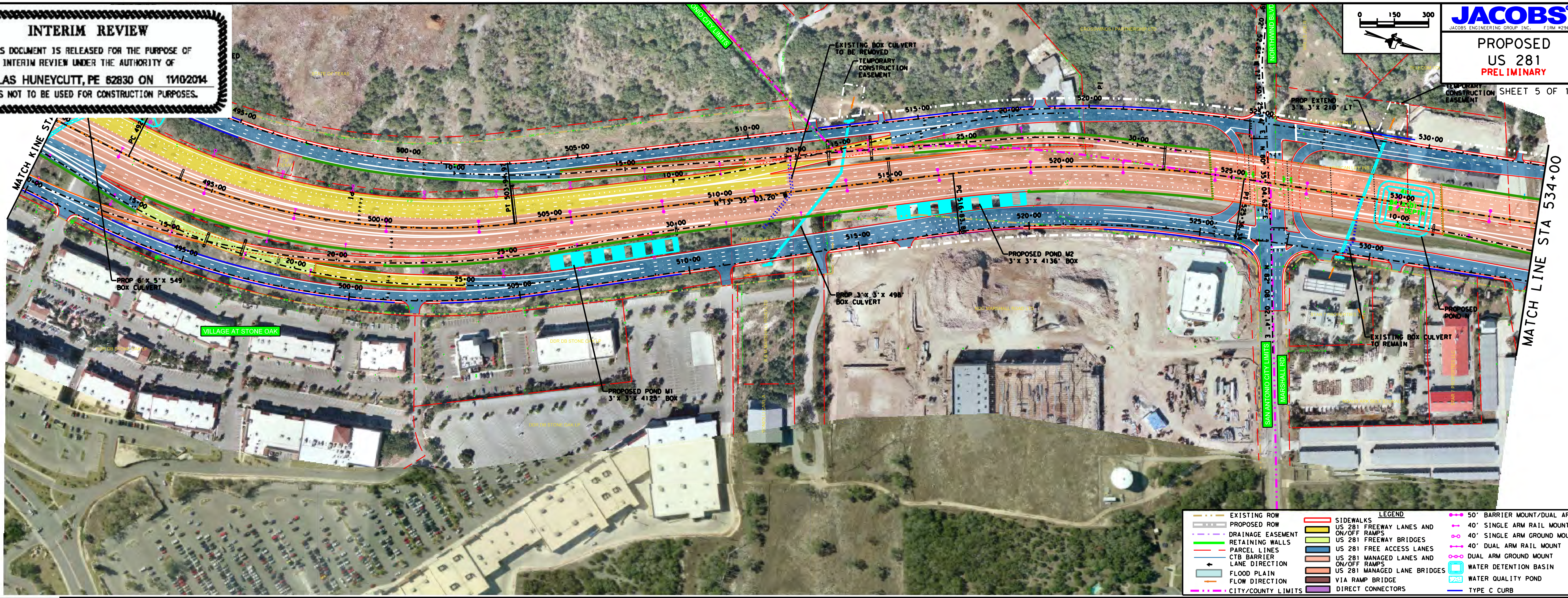

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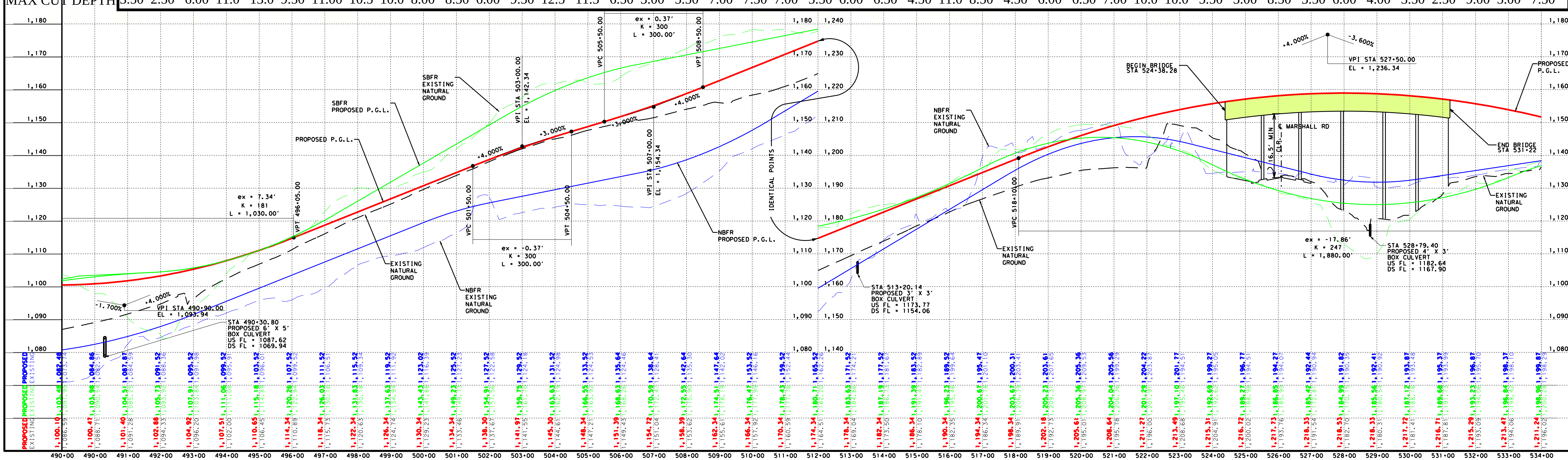

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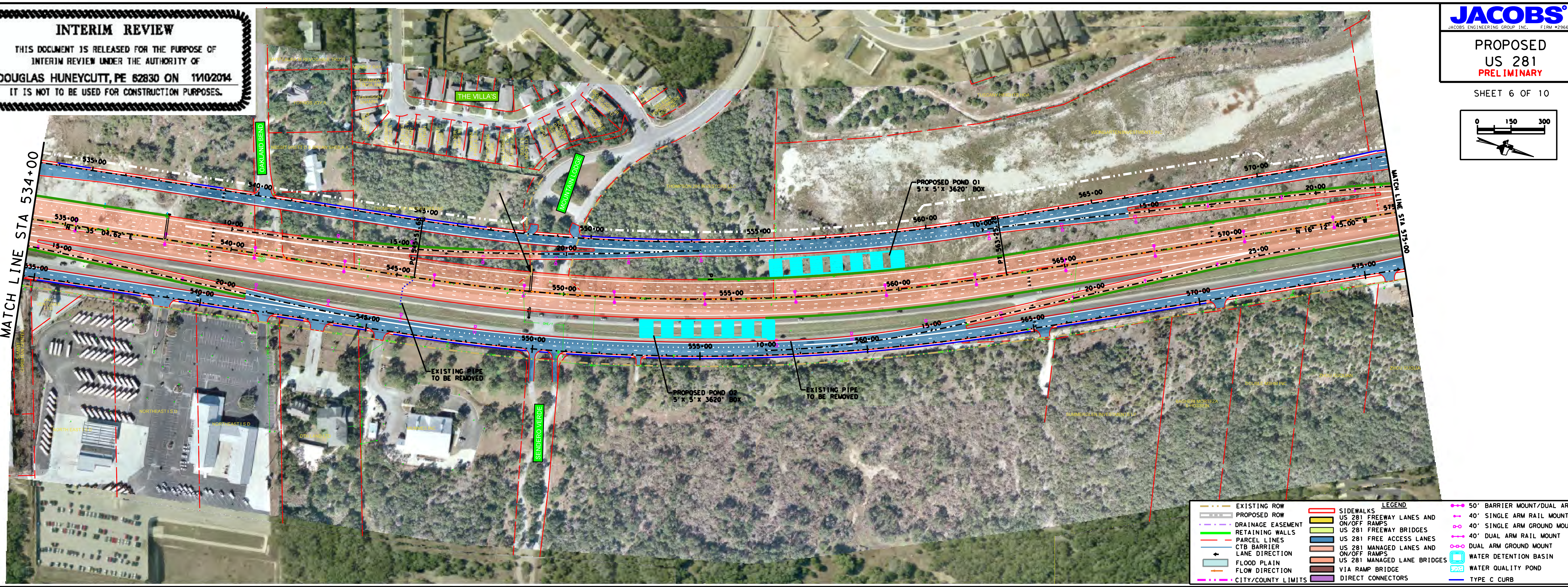

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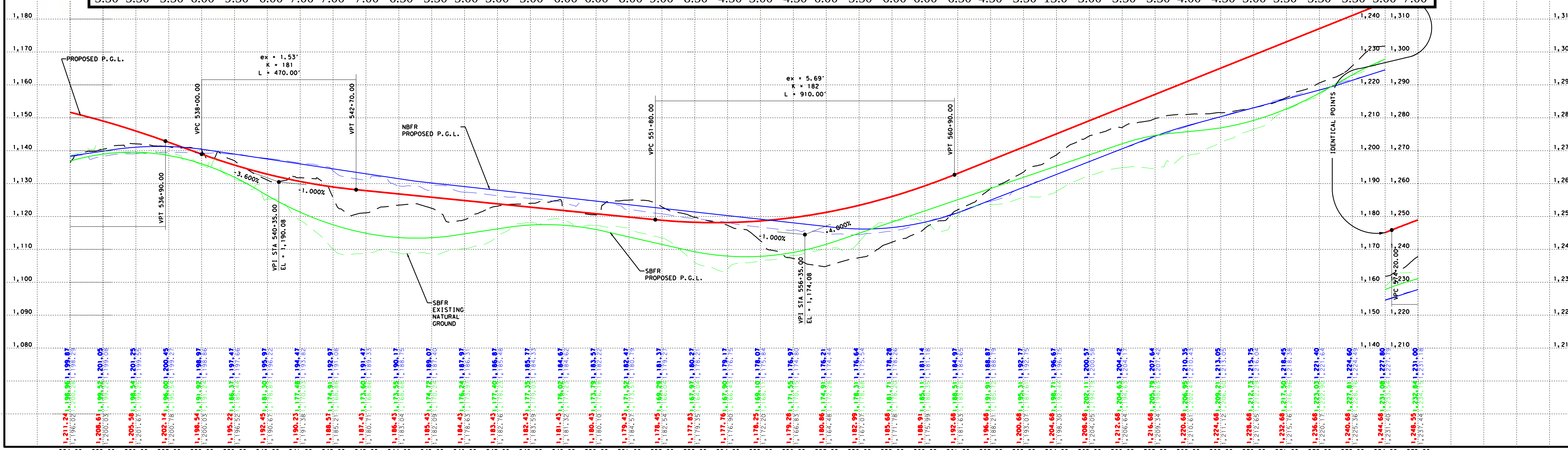

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SHEET 7 OF 10

MAX CUT DEPTH

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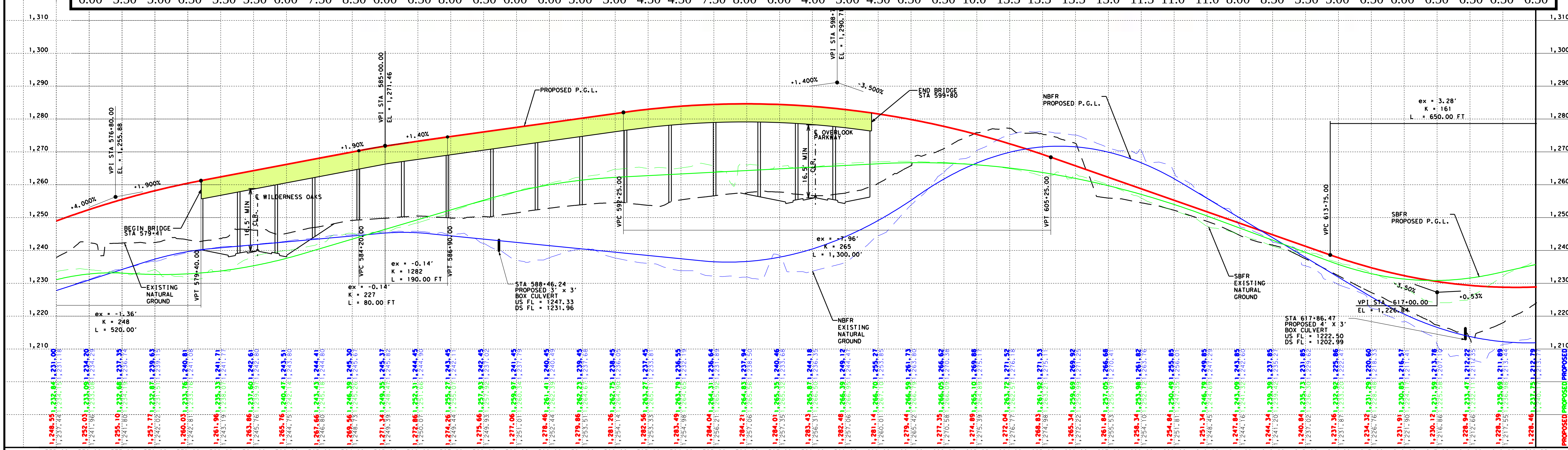

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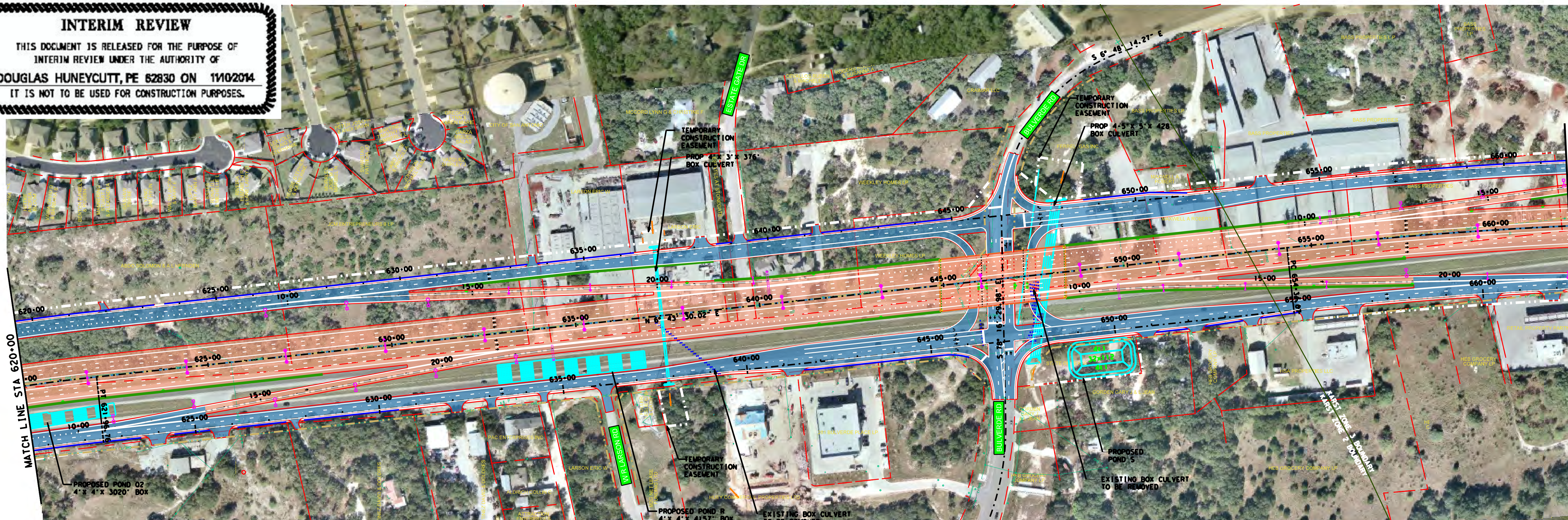
PROPOSED US 281

PRELIMINARY

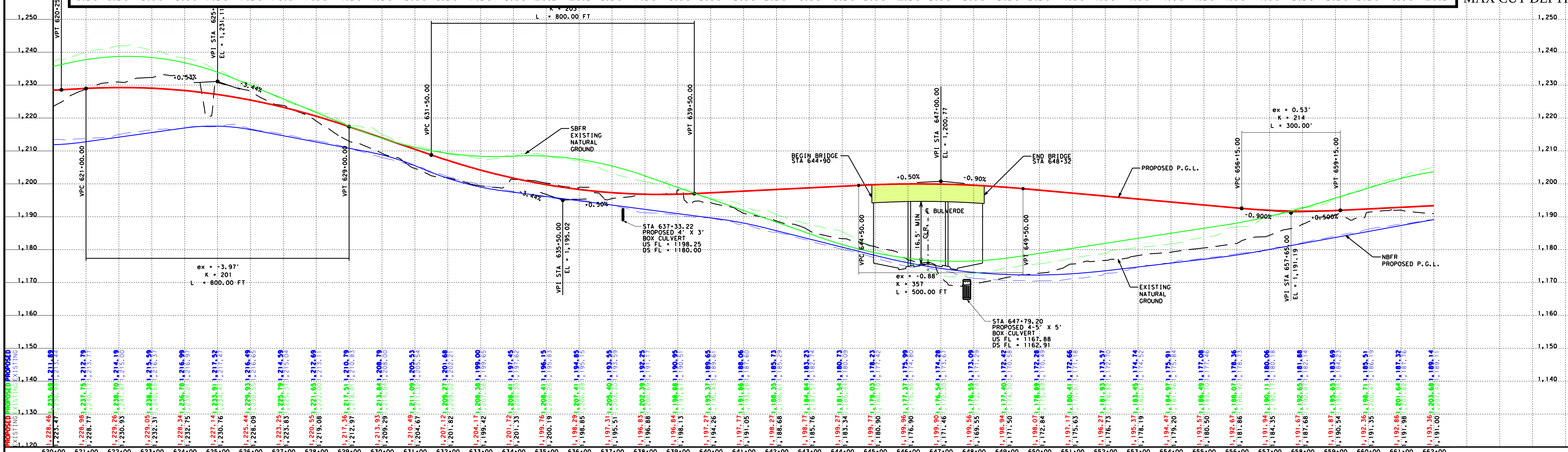
SHEET 8 OF 10



LEGEND

EXISTING ROW	SIDEWALKS	50' BARRIER MOUNT/DUAL ARM
PROPOSED ROW	US 281 FREEWAY LANES AND ON/OFF RAMPS	40' SINGLE ARM RAIL MOUNT
DRAINAGE EASEMENT	US 281 FREEWAY BRIDGES	40' SINGLE ARM GROUND MOUNT
RETAINING WALLS	US 281 FREE ACCESS LANES	40' DUAL ARM RAIL MOUNT
PARCEL LINES	US 281 MANAGED LANES AND ON/OFF RAMPS	DUAL ARM GROUND MOUNT
CTB BARRIER	US 281 MANAGED LANE BRIDGES	WATER DETENTION BASIN
LANE DIRECTION	VIA RAMP BRIDGE	WATER QUALITY POND
FLOOD PLAIN	DIRECT CONNECTORS	TYPE C CURB
FLOW DIRECTION		
CITY/COUNTY LIMITS		

6.50	6.50	8.00	8.00	7.50	7.50	70.0	7.00	4.50	4.50	5.00	6.50	7.50	8.00	10.5	10.5	8.50	7.50	6.00	5.00	5.00	5.50	6.00	6.50	5.00	2.50	3.00	3.00	3.50	3.50	4.00	4.00	4.00	4.00	4.50	4.00	4.00	5.50	5.50	5.50	6.00	10.5	MAX CUT DEPTH



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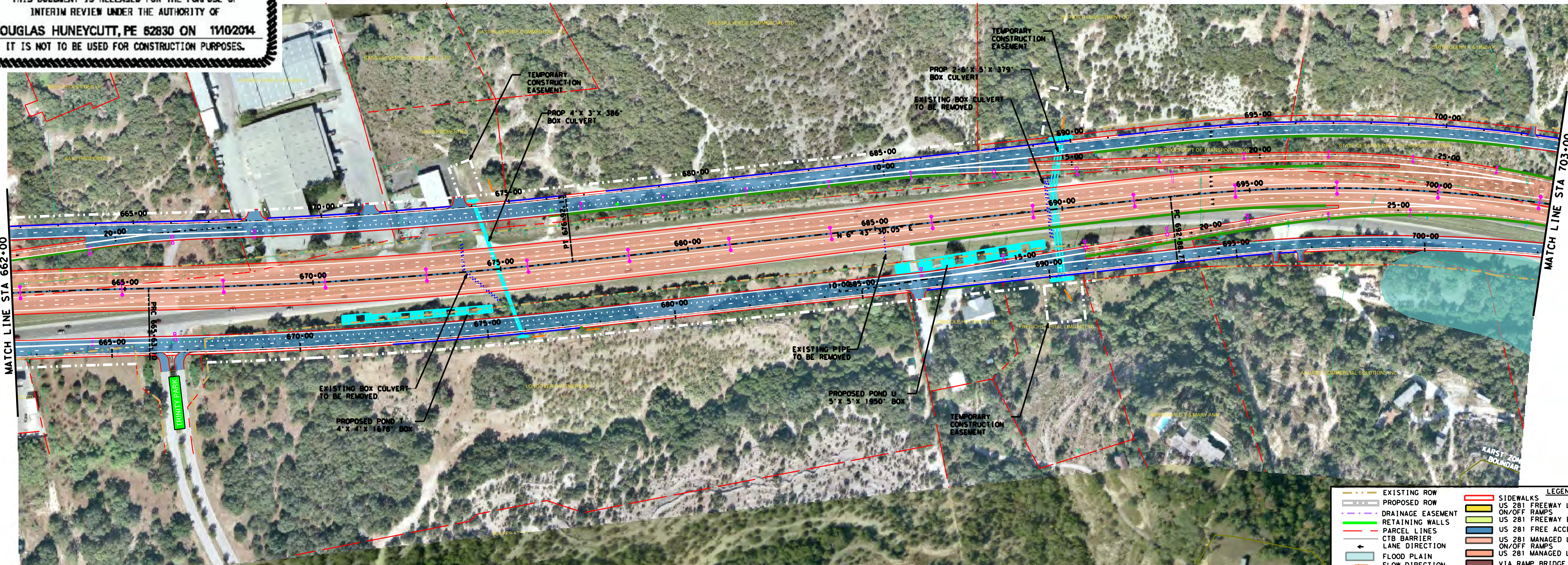
SHEET 9 OF 10



LEGEND

- EXISTING ROW
- PROPOSED ROW
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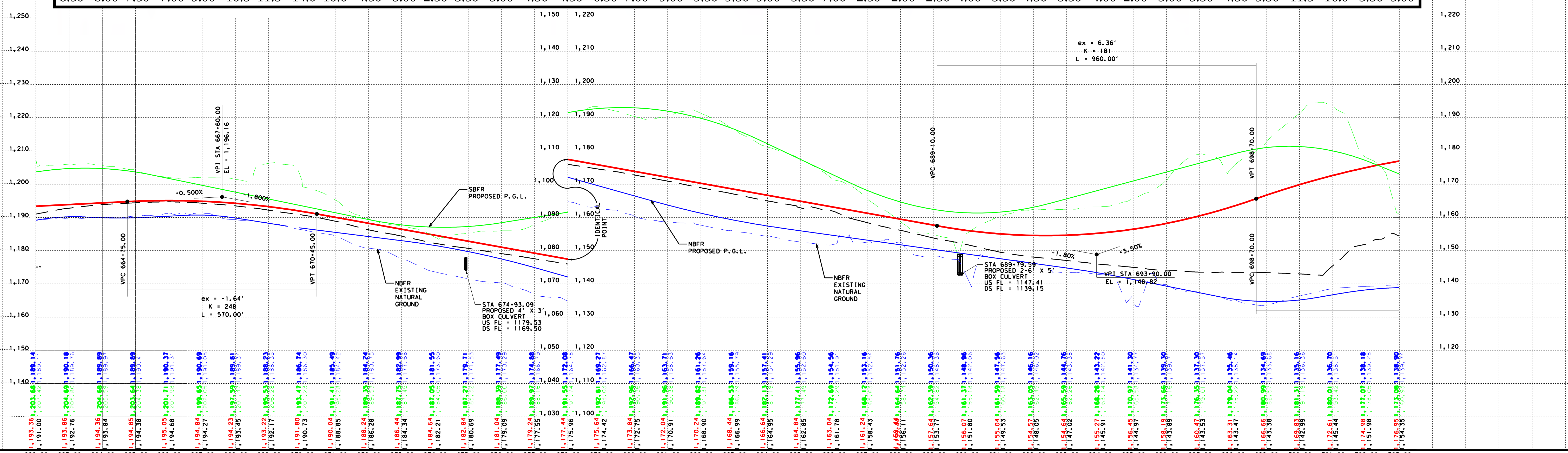
- RETAINING WALLS
- PARCEL LINES
- CTB BARRIER
- LANE DIRECTION
- FLOOD PLAIN
- FLOW DIRECTION
- CITY/COUNTY LIMITS
- SIDEWALKS
- US 281 FREEWAY LANES AND ON/OFF RAMPS
- US 281 FREEWAY BRIDGES
- US 281 FREE ACCESS LANES
- US 281 MANAGED LANES AND ON/OFF RAMPS
- US 281 MANAGED LANE BRIDGES
- VIA RAMP BRIDGE
- DIRECT CONNECTORS
- 50' BARRIER MOUNT/DUAL ARM
- 40' SINGLE ARM RAIL MOUNT
- 40' SINGLE ARM GROUND MOUNT
- 40' DUAL ARM RAIL MOUNT
- DUAL ARM GROUND MOUNT
- WATER DETENTION BASIN
- WATER QUALITY POND
- TYPE C CURB

8.50	8.00	7.50	7.00	9.00	10.5	11.5	14.0	10.0	4.50	5.00	2.50	3.50	3.00	4.50	4.50	6.50	7.00	9.00	9.50	9.50	9.00	5.50	7.00	2.50	2.00	2.50	4.00	5.50	4.50	5.50	4.00	2.00	3.00	5.50	4.50	5.50	11.5	16.0	3.50	3.00	MAX CUT DEPTH



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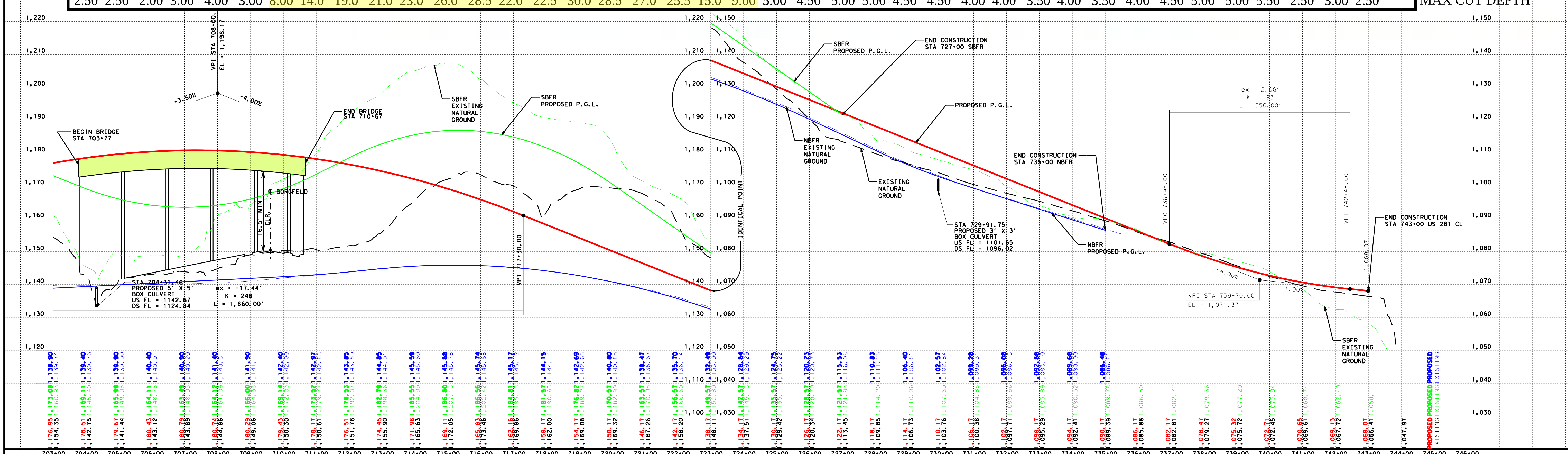
PROPOSED
US 281
PRELIMINARY

2.50	2.50	2.00	3.00	4.00	3.00	8.00	14.0	19.0	21.0	23.0	26.0	28.5	22.0	22.5	30.0	28.5	27.0	25.5	15.0	9.00	5.00	4.50	5.00	5.00	4.50	4.50	4.00	4.00	3.50	4.00	3.50	4.00	4.50	5.00	5.00	5.50	2.50	3.00	2.50

MAX CUT DEPTH



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Appendix B

Karst Investigations Report

ZARA ENVIRONMENTAL LLC
1707 West FM 1626, Manchaca, Texas 78652
www.zaraenvironmental.com

DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

Interior of a US 281 road cut cave

Prepared for:
Jacobs Engineering Group
2705 Bee Cave Rd Suite 300
Austin, TX 78746-5688

7 December 2010

Abstract

Field surveys and background research to assess potential endangered karst invertebrate species habitat were conducted in the vicinity of anticipated improvements to US 281 between Loop 1604 and Borgfeld Road in Bexar County, Texas. A total of 116 features were recorded during field surveys. Some of these were non-karstic, others were karstic but not considered potential habitat, some were open caves, and some were excavated to evaluate potential for karst invertebrate habitat. Sixty features were recommended for excavation; 15 excavation requests were not granted by landowners, and the other 45 were excavated. Thirteen caves and karst features, and one spring were biologically surveyed. Two additional springs were recommended for biological surveys but access was not granted. Ten of the features surveyed contained troglobites, and therefore are considered to be karst invertebrate habitat. Two caves are occupied by rare, non-listed species; they are Power Pole Hole and Stafford Cave. No federally-listed karst invertebrate species were encountered during this study, nor were any *Eurycea* salamanders found.

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Significant Features Outside of Buffer 6
Climate Analysis 6

Results 7

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Introduction

This karst[1] invertebrate technical report has been prepared as a component of a comprehensive document related to potential environmental impacts resulting from proposed improvements to US 281 in northern Bexar County. In addition to this document, a Geologic Assessment of the study area is also being prepared (Zara 2010).

Nine karst invertebrate species in Bexar County were listed as endangered by the US Fish and Wildlife Service (USFWS) on 26 December 2000 (USFWS 2000). Management areas, known as Karst Fauna Regions (KFRs), have been established for these species (Veni 1994). This project area falls within the Stone Oak KFR. Listed species known to occur in this KFR include the Madla Cave meshweaver *Cicurina madla*, the ground beetle *Rhadine exilis*, and the ground beetle *Rhadine infernalis*. Two species of state-threatened *Eurycea* salamanders (*E. neotenes* and *E. tridentifera*) currently under consideration for federal listing as endangered (USFWS 2009) are also known from the US 281 area. *E. tridentifera* is currently listed as threatened by the State of Texas. The US 281 corridor lies within 3 km (1.86 mi) of critical habitat units[2] (CHUs) 12, 13 and 21, designated for *Rhadine exilis* by USFWS.

Five karst zones have been established in the Bexar County area based on their likelihood of containing habitat for listed karst invertebrate species (USFWS 2006, modified from Veni 1992; 1994; 2002). These karst zones are defined as follows:

- Zone 1: Areas known to contain endangered karst invertebrate species
- Zone 2: Areas having a high probability of containing suitable habitat for endangered karst invertebrate species
- Zone 3: Areas that probably do not contain endangered karst invertebrate species
- Zone 4: Areas that require further research but are generally equivalent to Zone 3, although they may include sections that could be classified as Zone 2 or Zone 5 if more information becomes available
- Zone 5: Areas, both cavernous and non-cavernous, that do not contain endangered karst invertebrate species

The study area falls within Karst Zones 1 2, and 3. Total size of the study area was 551.7 ha (1,390 ac) with 53 % in Karst Zone 1, 34% in Karst Zone 2 and 13% in Karst Zone 3 (Figure 1).

In accordance with USFWS recommendations for projects proposed in potential habitat for listed karst species (USFWS 2006), a survey for caves and karst features[3] was performed in order to detect potential habitat for these species. Surveys were conducted within existing right-of-way (ROW) and on properties within 500 feet of the proposed project alternatives where right-of-entry (ROE) access was granted. Karst features meeting USFWS (2006) guidelines for warranting excavation and/or presence/absence surveys were excavated and surveyed where ROE was granted for that purpose as detailed in Table 1.

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[1] *Karst*: A landscape characterized by the dissolution of limestone bedrock, often resulting in the formation of sinkholes and caves.
[2] *Critical Habitat Unit (CHU):* a geographic area designated by USFWS that is inhabited by a federally listed species. Critical habitat is more specifically defined in section 3(5)(A)(i) of the Endangered Species Act as, "the specific areas within the geographic area occupied by as species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation and management of the species and (II) which may require special management considerations or protection" (USFWS 2003, 17172).
[3] *Karst feature:* A geologic feature formed by the solution of limestone. The term karst feature encompasses caves, sinkholes, fractures, springs and seeps, soil pipes, and solution cavities.

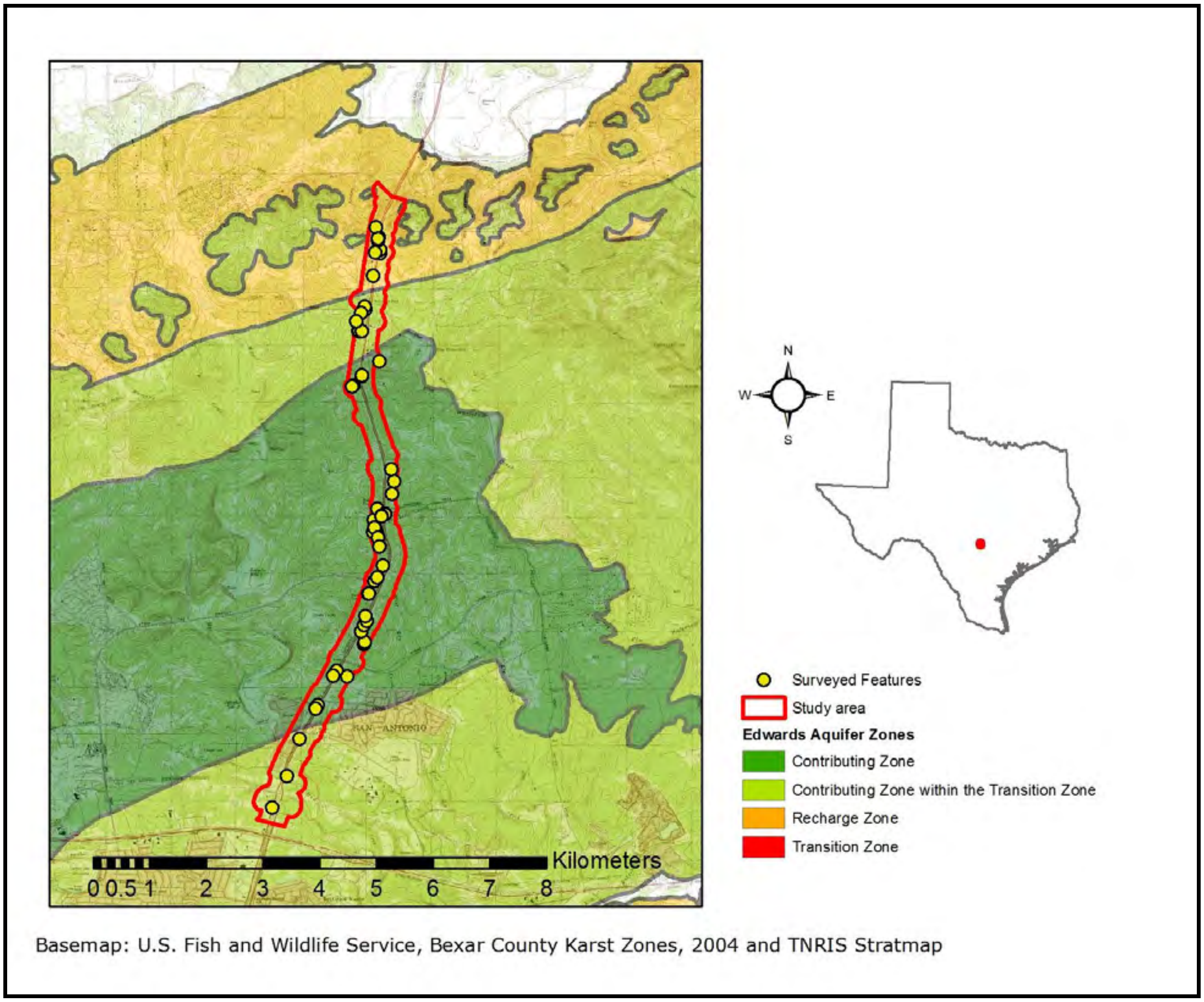

Figure 1. Map of US 281 species study area.

Methods

Background Data Collection

Information on the existing distribution of caves, karst features, and karst species within a 152 m (500 ft) buffer of proposed US 281 improvements was obtained from multiple sources. Records were acquired from the Texas Speleological Survey (TSS). Geospatial data files and documents from the Administrative Record for the 281 Environmental Assessment provided by Texas Department of Environmental Affairs Division (TxDOT ENV) were also obtained. An exhaustive search of Texas Commission on Environmental Quality (TCEQ) files to obtain all accessible previous Geologic Assessments performed in the study area was performed.

Karst Feature Survey

In addition to surveying the current US 281 right-of-way (ROW), an access request ("right of entry," or ROE) was made for all properties within the 152 m (500 ft) buffer. This request was performed by Jacobs Engineering Group. Properties with owners granting permission to enter the premises were surveyed for karst features. Extensive effort was expended on relocating and reassessing features within the ROW and on all properties where ROE was granted.

Karst survey methods followed protocols outlined in the Texas Commission on Environmental Quality (TCEQ) Instructions to Geologists for Geologic Assessments on the Edwards Aquifer Recharge/Transition Zones (TCEQ 2004) and USFWS Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence Surveys for Endangered Karst Invertebrates in Central Texas (USFWS 2006). A karst feature survey, as defined in as defined by Veni and Reddell (2002), Barrett (1999) and TCEQ (2004), was conducted in the right of way (ROW) and within the 152 m (500 ft) buffer on all properties where access had been granted. The survey area extended from Borgfeld Road in the north to a point just north of Loop 1604 in the south. The southern terminus of the search area adjoined the search area for a companion study being performed on Loop 1604. To perform surveys, two or more surveyors walked in a formation not more than 15 m (50 ft) apart searching for depressions and other indications of potential subterranean habitat. All surveys were supervised by an individual permitted under USFWS Section 10(a)(1)(A) to conduct surveys for endangered karst invertebrates.

All features were documented on an field evaluation form, and positional data were recorded using a hand held Magellan eXplorist model consumer grade Global Positioning System (GPS) receiver, and checked with field maps based on digital ortho-imagery. No differential correction was performed on the GPS data before being transferred to a Geographic Information System.

Excavation and Mapping

Recommendations made by USFWS (2006), paraphrased here, were used to help determine whether features would be excavated in order to determine the potential for endangered species habitat:

If either of the following criterion is met, then excavation is warranted:

A. Feature contains leaf litter or loose, modern soils and rocks.
B. Feature exhibits airflow, channelized recharge, collapse development, loose fill to a depth of greater than 30 cm (1 ft), or clean-washed rocks.

If neither of the above criteria were met, but at least two of the following criteria were met, then excavation is warranted:

C. Feature is developed along a fracture.
D. Feature is more than 2 m (6.6 ft) in length.
E. Feature is more than 1 m (3.3 ft) deep.
F. Feature is similar in appearance to nearby caves in similar geologic setting.
G. A potentially humanly-enterable void is visible.

Table 1 shows whether excavation was warranted for each feature under criteria A and B. In cases where the criteria were not met and additional factors also did not lead to the recommendation of excavation, seven characteristics named by USFWS (2006) and paraphrased here of features not likely to contain suitable endangered species habitat were considered:

H. All or nearly all of the interior surfaces covered with calcite speleothems.
I. Feature floor less than 1.5 m (4.9 ft) below the surface.
J. Absence of troglobites and troglophiles.
K. Features are dry or do not have evidence of modern water flow.
L. Features have fewer than 10 cave crickets.
M. Absence of airflow.
N. Feature not formed by a collapse or related to a collapse.

In addition to these considerations, we evaluated obvious or potential connections to mesocavernous voids[4] in all features. All excavations were performed under the direct supervision of a biologist holding a USFWS 10(a)(1)(A) permit for endangered karst species. Excavations were conducted using hand and power tools. No heavy machinery was used. Features were excavated until one of three conditions was met:

1. a distinct terminus was reached with no mesocavernous voids or drains extending off.
2. suitable habitat (i.e., cave passage) was reached for sampling karst invertebrate species.
3. some type of mesocavernous void continued on from the accessible portion of the feature, but the effort and expense to continue excavation did not justify doing so.

Specifics of the extent and nature of effort expended for each feature are provided in the results section. Except during surveys or excavation, the feature entrance was covered with plywood and black plastic sheeting that was held in place with rocks. The purpose of this covering was to buffer against fluctuations in surface temperature, humidity, and sun exposure. Fauna observations and collections were made as the opportunity arose during excavation activities.

Post-excavation sketches were made for those features that were excavated, and these were used to describe post-excavation dimensions. Features where biological evaluations took place were mapped in accordance with standard cave mapping methods (Dasher 1994). Locations of glue traps and climate stations, as well as original (pre-excavation) floor levels, are shown on these maps. Features over 5 m (16 ft) long were considered to be caves, and were given cave names in most cases. Dimensions of cave and feature entrances at the surface are given, and lengths and depths of caves are shown on cave

[4] *Mesocavernous voids*: also referred to throughout the document as simply "mesocaverns," are small openings that are not humanly enterable. These voids may allow the movement of air, water, and invertebrates through the subsurface.

maps. The length of a cave or karst feature indicates to total traversable extent. The depth refers to the difference in elevation between the lowest and highest parts.

Biological Surveys

Terrestrial karst invertebrate presence/absence survey protocols utilized during this study were developed by USFWS (2006). Surveys were conducted between 14 June and 1 October 2010, within seasons recommended by USFWS (2006), at features determined to have the potential to contain karst invertebrate habitat. Each of (at least) three surveys conducted at each qualifying karst feature were separated by a week-long period of inactivity at the feature. In cases where the site showed evidence of recent flooding, additional surveys were conducted. Between surveys, the features were covered with plywood and black plastic sheeting held down with rocks.

Visual searches for organisms were performed by thoroughly inspecting all exposed surfaces within the void, including the walls, floor, and by examining the insides of cracks and crevices using a headlamp. The undersides of loose rocks were inspected with the naked eye, occasionally aided by the use of a jeweler's loupe for magnification. The floor substrate, including substrate underneath rocks, was also thoroughly examined for organisms.

Tomcat® or similar consumer-type glue traps, which use an adhesive that causes fauna to stick to the trap, were placed in the features and collected on the next visit. Locations of traps are indicated on the feature map. Small amounts of food bait were placed on the traps to attract fauna. Glue traps have been found to be an effective method of supplementing visual searches, since they allow for continual sampling even in the absence of a researcher. A number of organisms recorded during other surveys have been observed or captured on glue traps, including subterranean silverfish (*Texoreddellia*), millipedes (*Cambala*), flies (Diptera), mice (*Peromyscous*), isopods (*Armadillidium, Porcellio, Brackenridgia*), cave crickets (*Ceuthophilus*), ants (Formicidae), cockroaches (Blattaria), springtails (Collembola), true bugs (Hemiptera), beetles (Coleoptera), and spiders (*Cicurina*) (TxDOT 2009).

Any fauna seen in the caves or features, or found in the traps, were noted on field sheets, and in many cases specimens were collected for further identification and to create a museum record of notable fauna from each site. All specimens collected will be deposited at the Texas Memorial Museum at the end of the project. Taxa identified at each feature are included in the feature descriptions located in the Results section of this report.

Identification, ecological classification, and curation of material collected were largely performed by James Reddell of the Texas Memorial Museum. Darrell Ubick (California Academy of Sciences) and James Cokendolpher (Museum of Texas Tech University) assisted with the identification of troglobitic harvestmen and spiders. Subterranean fauna were identified to species level whenever possible, other fauna encountered (i.e. ants, flies) were identified to the ordinal level.

Temperatures used to calculate relative humidity (RH) were measured using a fan-cooled wet and dry bulb psychrometer (Psychro-Dyne®, Industrial Instruments & Supplies, PO Box 416, County Line Industrial Park, Southampton, PA 18966). Atmospheric pressure was measured using a digital barometer built into the Silva Tech$_4$o thermometer. Measurements were taken in the shade at ground level 5 m (16.4 ft) from the cave or feature entrance and inside the feature at multiple stations if the feature was large enough to warrant it. Surface and subsurface RH values were calculated from bulb measurements and atmospheric pressure.

Sampling of springs for *Eurycea* salamanders and stygobitic invertebrates was conducted using four methods, including visual searches, kick-netting, and two different methods of trapping. Visual searches performed in the water around the spring outlets included inspecting the top of the substrate as well as inspecting under rocks and sunken leaves. Kick-netting of the substrate involved forcing sunken debris and aquatic plant matter into nets, and then carefully searching the net contents. Mop heads, which were used successfully in a similar study by Gibson et al. (2008) to detect federally-listed aquifer species, were left at and adjacent to the spring outlets. The mop heads were checked periodically by immersing them in a tub of water and rinsing them out, then searching the rinse water. Bottle traps constructed out of a plastic drink bottle with the neck inverted such that it is easy for a salamander to enter, while making escape difficult,, were baited with bits of food and inserted at or near the spring orifice and checked periodically during the sampling period.

Significant Previously Recorded Features
Known caves and karst features within the 152 m (300 ft) buffer where ROE was not obtained or are now destroyed were reviewed for potential biological significance.

Significant Features Outside of Buffer
In order to help obtain an overview of sensitive karst species habitat in the area adjacent to the study area, a desktop review of known caves and karst features outside of the 152 m (300 ft) buffer was also conducted out to 304 m (1000 ft) from the ROW.

Climate Analysis
The USFWS provides guidelines for recommended season and weather conditions that increase the likelihood of detecting karst invertebrate species (USFWS 2006). These recommendations were taken into consideration for each feature where biological surveys were conducted, and the results of the climate analysis for those features are presented in Appendix H.

Recommended weather condition criteria for sampling include:
1) average weather (temperature and rainfall) for time of year
2) surface air temperatures during the previous week between 4.4° C (40° F) and 37.8° C (100° F)
3) lack of drought conditions
4) recent rainfall
5) absence of recent, extensive, local flooding

The first criterion (average weather for time of year) was evaluated by comparing the 30 year average high and low temperature data to data collected from within the sampling period. The second criterion, which outlines the daily temperature limits for the week preceding each biological survey, was evaluated by recording the high and low temperatures that occurred beginning one week prior to the first survey and continuing through the last survey. The third criterion, lack of drought conditions, was evaluated according to the Palmer hydrologic index and indices of soil moisture, stream flow, precipitation, and vegetation health. The fourth criterion, recent rainfall, was evaluated based on precipitation data obtained from the National Oceanic and Atmospheric Administration (NOAA). The fifth and final criterion, absence of recent extensive local flooding, was evaluated by analyzing local precipitation data and on-site observations.

Results

Background Data

A review of previous reports and literature on karst features in the project area revealed that previous karst feature surveys and inventories had been performed in portions of the study area. Geospatial files and documents from the Administrative Record for the 281 Environmental Assessment provided by TxDOT ENV contained locational information for these features. A significant amount of effort was expended to visit and/or document all of these historic features, which were assigned new feature names corresponding to this project when they were considered to have potential to contain karst invertebrate habitat or were to be recorded for purposes of the Geological Assessment. Previously identified features that had no potential to lead to karst invertebrate habitat, or features located on properties not granting ROE, were not evaluated but are presented as historic features in Appendix A.

Karst Feature Surveys

Access requests were made to landowners within the 152 m (500 ft) buffer of the proposed ROW, and those properties where access was granted were surveyed. Properties where owners granted access for karst feature surveys are identified in Appendix B.

Pedestrian karst feature surveys were completed for the unpaved portions of the US 281 ROW and for all properties allowing access within the 152 m (500 ft) buffer of the proposed ROW between Loop 1604 and Borgfeld Road. A total of 116 features were recorded and sketched (Appendix C) during field surveys, of these 26 were recorded solely for the purposes of developing the Geologic Assessment. Feature locations are provided in Appendix D, and mapped in Appendix E and F.

Excavation and Biological Surveys

Features were recommended for excavation based on the guidelines provided by USFWS (2006), as indicated in Table 1. Site-specific excavation effort details are provided with the description of each site, below.

Presence/absence surveys were conducted at 13 terrestrial sites following USFWS (2006) protocols and at one spring site. The single spring site, 281-003, was sampled for *Eurycea* salamanders six times, but none were found. Ten sites visited during this study contained karst invertebrate habitat, as evidenced by the presence of at least one confirmed troglobitic species. A troglobite sight record at feature 281-085 and a historical troglobite record for Feature 23 Cave where ROE was not obtained bring that total to 12. Most troglobite specimens obtained were of relatively common animals, such as the subterranean silverfish *Texoreddellia* sp. and the millipede *Cambala speobia*. Two rare species, a troglobitic harvestman from features 281-070 and a blind *Cicurina* spider from feature 281-080, were detected. Taxonomic verification for these species was performed by Darrell Ubick and James Cokendolpher (Appendix G).

None of the federally-listed karst invertebrate species or *Eurycea* salamander species were encountered during this study, and none are known to occur within ROW and buffer areas.

Table 1. Summary table of USFWS conditions warranting excavation for features discovered during karst feature. Dashes are entered for sites that were not potential karst features or were already open caves not needing excavation.

Excavation warranted	If either condition is met		If at least two conditions are met					Excavation is not warranted if all conditions are met						
ID/Condition:	Contains modern fill (A)	Airflow, collapse, loose fill (B)	Developed on fracture (C)	> 2 m long (D)	> 1 m deep (E)	Similar to other caves (F)	Visible void (G)	All surfaces speleothems (H)	Floor < 1.5 m from surface (I)	No fauna (J)	Dry (K)	< 10 cave crickets (L)	No airflow (M)	No collapse (N)
281-001	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-002									x	x		x	x	x
281-003									x	x		x	x	x
281-004	x								x	x	x	x	x	
281-005	x								x	x	x	x	x	
281-006									x	x	x	x	x	x
281-007									x		x	x	x	x
281-008									x	x	x	x	x	x
281-009	x						x		x	x	x	x	x	
281-010								x	x	x		x	x	x
281-011	x								x	x	x	x	x	
281-012									x	x		x	x	x
281-013	x						x		x	x	x	x	x	x
281-014									x	x	x	x	x	
281-015	x								x		x	x	x	
281-016		x			x				x	x	x	x		x
281-017									x	x		x	x	x
281-018	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-019	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-020	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-021	x								x	x	x	x	x	
281-022	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-023	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-024	x								x	x	x	x	x	
281-025	x		x	x						x	x	x	x	x
281-026	x	x							x	x	x	x	x	
281-027	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-028	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-029	x	x							x	x	x	x	x	

Excavation warranted	If either condition is met		If at least two conditions are met					Excavation is not warranted if all conditions are met						
ID/Condition:	Contains modern fill (A)	Airflow, collapse, loose fill (B)	Developed on fracture (C)	> 2 m long (D)	> 1 m deep (E)	Similar to other caves (F)	Visible void (G)	All surfaces speleothems (H)	Floor < 1.5 m from surface (I)	No fauna (J)	Dry (K)	< 10 cave crickets (L)	No airflow (M)	No collapse (N)
281-030	x								x	x	x	x	x	
281-031	x			x					x	x	x	x	x	
281-032	x	x							x	x	x	x	x	
281-033	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-034	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-035	x			x					x	x	x	x	x	
281-036	x								x	x	x	x	x	
281-037				x		x	x		x	x		x	x	
281-038	x	x							x	x	x	x		
281-039	x	x							x	x	x	x		
281-040	x								x	x	x	x	x	
281-041	x		x						x	x	x	x	x	
281-042	x								x	x	x	x	x	x
281-043	x								x	x	x	x	x	
281-044	x			x	x				x	x	x	x	x	
281-045	x			x			x		x	x	x	x	x	x
281-046	x								x	x		x	x	
281-047	x								x	x	x	x	x	
281-048	x	x		x					x	x	x	x		
281-049	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-050	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-051	x		x						x	x	x	x	x	x
281-052										x	x	x	x	x
281-053	x	x		x					x	x	x	x	x	
281-054									x	x	x	x	x	x
281-055		x	x							x	x	x	x	x
281-056	x								x	x	x	x	x	x
281-057	x								x	x	x	x	x	x
281-058		x		x					x	x	x	x	x	
281-059										x	x	x	x	x
281-060									x	x	x	x	x	x

Excavation warranted	If either condition is met		If at least two conditions are met					Excavation is not warranted if all conditions are met						
ID/Condition:	Contains modern fill (A)	Airflow, collapse, loose fill (B)	Developed on fracture (C)	> 2 m long (D)	> 1 m deep (E)	Similar to other caves (F)	Visible void (G)	All surfaces speleothems (H)	Floor < 1.5 m from surface (I)	No fauna (J)	Dry (K)	< 10 cave crickets (L)	No airflow (M)	No collapse (N)
281-061						x			x	x	x	x	x	x
281-062				x		x	x			x	x	x	x	x
281-063	x						x		x	x	x	x	x	x
281-064	x	x							x	x	x	x	x	
281-065	x	x	x						x	x	x	x		x
281-066									x	x	x	x	x	x
281-067	x	x							x	x	x	x	x	
281-068	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-069									x	x	x	x	x	x
281-070		x				x			x	x	x	x		x
281-071				x	x	x			x	x	x	x	x	x
281-072									x	x	x	x	x	x
281-073		x		x		x			x	x	x	x	x	x
281-074						x			x	x	x	x	x	x
281-075	x	x				x			x	x	x	x		x
281-076									x	x	x	x	x	x
281-077			x						x	x	x	x	x	x
281-078		x				x			x	x	x	x		x
281-079									x	x	x	x	x	x
281-080		x	x		x		x					x		x
281-081									x	x		x	x	x
281-082									x	x	x	x	x	x
281-083	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-084				x			x		x	x	x	x	x	x
281-085				x		x				x	x	x	x	x
281-086				x					x	x	x	x	x	x
281-087								x		x		x	x	x
281-088		x		x		x	x		x	x		x		x
281-089		x		x		x	x		x	x		x		x
281-090					x		x					x	x	x
281-091				x			x		x	x		x	x	x

Excavation warranted	If either condition is met		If at least two conditions are met					Excavation is not warranted if all conditions are met						
ID/Condition:	Contains modern fill (A)	Airflow, collapse, loose fill (B)	Developed on fracture (C)	> 2 m long (D)	> 1 m deep (E)	Similar to other caves (F)	Visible void (G)	All surfaces speleothems (H)	Floor < 1.5 m from surface (I)	No fauna (J)	Dry (K)	< 10 cave crickets (L)	No airflow (M)	No collapse (N)
281-092	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-093	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-094				x					x	x	x	x	x	x
281-095			x		x				x	x		x	x	x
281-096					x					x	x	x	x	x
281-097	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-098			x						x	x	x	x	x	x
281-099	x								x		x			
281-100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-101	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-102										x	x	x	x	x
281-103	x	x							x	x	x	x	x	x
281-104			x							x	x	x	x	x
281-105										x	x	x	x	x
281-106	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-107	x									x	x	x	x	
281-108	x								x	x	x	x	x	x
281-109	x								x	x	x	x	x	x
281-111	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-112	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-113	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-114	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-115	-	-	-	-	-	-	-	-	-	-	-	-	-	-
281-116	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Conditions: A=Feature contains leaf litter or loose, modern soils and rocks; B=Feature exhibits airflow, channelized recharge, collapse development, loose fill to a depth of >30 cm, or clean-washed rocks; C=Feature is developed along a fracture; D=Feature is more than 2 m (6.5 ft) in length; E=Feature is more than 1 m (3.2 ft) deep; F=Feature is similar in appearance to nearby caves in similar geologic settings; G=A potentially humanly-enterable void is visible; H=All surfaces are covered with calcite speleothems and no black sediment is present; I=Floor occurs less than 1.5 m (4.9 ft) below the surface; J=No troglobites or troglophile species are present; K=Feature is dry (no notable moisture or dampness on surfaces or sediments, no evidence of occasional moisture or speleothem development); L=Fewer than 10 cave crickets; M=Absence of airflow; N=not collapse-formed or related to a collapse

281-001, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-002, spring This is a spring that lies just outside of the eastern US 281 right of way, south of Borgfeld Road. Part of the spring pool is within the ROW, but the apparent spring source is on private land where right of entry was not granted (Figure 2). The spring appears to emerge from sediments, with no obvious single source. The spring pool measured 2 by 7 m (6.6 by 23 ft) when first recorded on 26 February 2010. Surface flow from the spring sank into sediments just downstream of the pool. While any spring in this area is potential habitat for *Eurycea* salamanders, the apparent lack of a bedrock portal for salamanders to retreat into makes that unlikely.

Figure 2. View of the spring pool at feature 281-002.

281-003, spring This spring is located along the eastern US 281 ROW just south of Borgfeld Road. There are five distinct spring sources; four of these emerge from sediment in an area that is 7 m (23 ft) long by 2 m (6.6 ft) wide by 0.3 m (1 ft) deep. The fifth emerges from a weep-hole pipe at the base of a concrete skirt constructed as part of the highway (Figure 3). The source of this water is unknown. The spring pool is bisected by the ROW limit. This site was considered to be potential habitat for *Eurycea* salamanders and was sampled on 13 May, 20 May, 2 June, 11 June, 16 June, and 25 June 2010. No salamanders were found during these surveys.

Figure 3. View of the spring pool at feature 281-003.

281-004, closed depression This is a closed depression that is situated on private property where right of entry was not granted. It is just across a fence line at the base of a persimmon tree (Figure 4). The feature is 0.7 m (2.3 ft) long, 0.5 m (1.6 ft) wide, and 0.25 m (0.8 ft) deep. It may be a solutional sinkhole, or it could be an animal burrow. It was recommended for excavation, but no right of entry was available.

Figure 4. View of feature 281-004 through fence.

281-005, non-karst closed depression/animal burrow This closed depression is mostly in the ROW, but is crossed by a fence and is partially on private property (Figure 5). A hackberry tree is growing out of one side of it. It is 1.5 m (4.9 ft) long, 0.7 m (2.3 ft) wide, and 0.2 m (0.7 ft) deep. Excavation was conducted on 10 September 2010 for 1.5 person-hours and 0.15 m^3 (5.3 ft^3) of material was removed. It was determined to be a burrow made by animals exploiting the roots of the hackberry tree rather than a karst feature

(Figure 6). Post-excavation dimensions of were 1.5 m (4.9 ft) long, 1 m (3.8 ft) wide, and 0.5 m (1.6 ft) deep. A list of fauna encountered in 281-005 can be found in Table 2.

Table 2. Taxa encountered in feature 281-005.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(1 penultimate male, 1 immature)
		Dictynidae	*Cicurina* (eyed)
Isopods	Isopoda	Armadillidiidae*	

*sight identification

Figure 5. Overview of feature 281-005. Chain link fence can be seen crossing the feature.

Figure 6. Feature 281-005 after excavation. It is a burrow made by animals exploiting a root system.

281-006, enlarged fracture This feature is in the road cut on the west side of US 281. The entrance to it is 0.8 m (2.6 ft) wide, 0.4 m (1.3 ft) high, and it extends into the road cut for 1 m (3.3 ft) (Figure 7). It is an enlarged fracture with no infill (Figure 8). Harvestmen (*Leiobunum townsendi*) were observed in this feature. This feature was not recommended for excavation (Table 1).

Figure 7. Overview of feature 281-006.

Figure 8. Interior of feature 281-006.

281-007, solution cavity/enlarged bedding plane This feature is situated in the road cut on the west side of US 281. The entrance to the feature is 0.7 m (2.3 ft) wide, 0.5 m (1.6 ft) high, and it extends into the road cut for 0.5 m (1.6 ft) (Figure 9). It is an enlarged bedding plane with no infill (Figure 10). A list of fauna encountered in 281-007 can be found in Table 3. This feature was not recommended for excavation (Table 1).

Table 3. Taxa encountered in feature 281-007.

Taxa	Order	Family	Species
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Gastropods	Stylommatophora*	undetermined	

*sight identification

Figure 9. Overview of feature 281-007.

Figure 10. Interior of feature 281-007.

281-008, solution cavity/enlarged bedding plane This is an enlarged bedding plane feature in the road cut on the west side of US 281 (Figure 11). The entrance is 0.4 m (1.3 ft) wide, 0.1 m (0.3 ft) high, and it extends into the road cut for at least 1.5 m (4.9 ft) (Figure 12). It is developed in pulverulitic limestone and has no sediment infill. This feature was not recommended for excavation (Table 1).


Figure 11. Overview of feature 281-008.


Figure 12. Interior of feature 281-008.

281-009, closed depressions This is a pair of closed depressions on private property on the west side of US 281 (Figure 13). The feature measures 1.5 by 1 m (4.9 ft by 3.8 ft), and is 0.3 m (1 ft) deep (Figure 14). It may be karstic in origin, or it may have an anthropogenic origin related to a nearby natural gas pipeline. Excavation would be needed to make that determination, and was recommended. ROE for excavation purposes was not granted.

Figure 13. Overview of feature 281-009.

Figure 14. Interior of feature 281-009.

281-010, spring This is a seep spring located on private property on the west side of US 281 (Figure 15). It flows from the travertine-covered base of a 3 m (9.8 ft) tall cliff in an area that is 2 m (6.6 ft) long by 1 m (3.3 ft) wide, but it does not have an identifiable portal (Figure 16). A small amount of water was flowing from it when assessed on 1 March 2010. It is possible habitat for *Eurycea* salamanders, but not likely due to the apparent lack of a portal. It was not sampled for salamanders due to revocation of ROE.


Figure 15. Overview of feature 281-010.

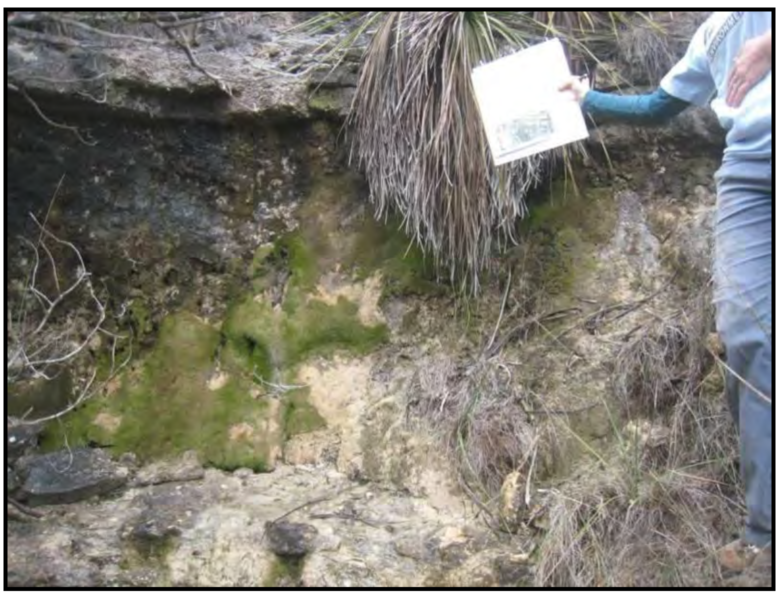
Figure 16. Feature 281-010 exhibits travertine deposition.

281-011, non-karst closed depression This depression is located on private property between a house and some storage units. When first located it was 1.5 m in diameter and 0.7 m deep, and filled with loose rocks (Figure 17) and snakes. Excavation was recommended to determine its origin. This was conducted on 10 August 2010. During this excavation effort, 9.25 person-hours of effort were expended and 1.25 m^3 (44 ft^3) of material was removed. This resulted in a rectangular depression 2.5 m (8.2 ft) long, 1.5 m (4.9 ft) wide, and 1 m (3.3 ft) deep, with a floor of hard-packed soil (Figure 18). Trash was removed from this excavation, and a rusty metal pipe leads into it (Figure 19). This feature appears to be some kind of old septic facility, and is not karst-related. A list of fauna encountered in 281-011 can be found in Table 4.

Table 4. Taxa encountered in feature 281-011.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed, 1 female)
		Dictynidae	*Cicurina* undetermined (eyed)
Millipedes	Julidia	Parajulidae	undetermined
Centipedes	Geophilomorpha	undetermined	
Snakes	Sqaumata	Colubridae	*Thamnophis* sp. *

Figure 17. View of feature 281-011 prior to excavation.

Figure 18. View of feature 281-011 after excavation.

Figure 19. Corroded metal pipe leading into feature 281-011.

281-012, spring This is a spring that emerges from two small bedrock openings in the middle of a creek bed that are 0.2 m (0.7 ft) in diameter. When the site was recorded on 1 March 2010, water was flowing from both the spring orifices and from upstream in the creek (Figure 20). It is not known if the water coming from the spring is merely pirated from the stream flow nearby, or if it has a more distant source. The spring has a well-defined bedrock orifice (Figure 21), which is possible habitat for threatened *Eurycea* salamanders; however it was not sampled due to revocation of ROE.

Figure 20. Overview of spring 281-012. Two spring outlets are present along the bedding plane that cuts diagonally across the picture.

Figure 21. One of two spring outlets at feature 281-012.

281-013, solutional sinkhole This is a karst feature that was initially 0.4 m (1.3 ft) long and 0.3 m (1 ft) wide. It was developed in bedrock, and the bedrock belled out in shape toward the floor 0.15 m (0.5 ft) below the surface (Figure 22). It was filled with fine soils and leaf litter. Excavation was conducted on 11 August 2010 utilizing 9.75 person hours of effort. The feature was enlarged using a jackhammer to a post-excavation size of 0.75 m (2.5 ft) by 1 m (3.3 ft) with a depth of 0.75 m (2.5 ft), where a floor of bedrock and hard-packed clay was encountered (Figure 23). No mesocavernous voids extended from the feature. A list of fauna encountered in 281-013 can be found in Table 5.

Table 5. Taxa encountered in feature 281-013.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed, 2 immature)
Centipedes	Geophilomorpha	undetermined	
Isopods (surface)	Isopoda*	undetermined	
Springtails	Collembola*	Entomobryidae	*Pseudosinella violenta**

*sight identification

Figure 22. Overview of feature 281-013.

Figure 23. Feature 281-013 after excavation, showing solid floor.

281-014, closed depression This is a depression that when initially assessed was 1.5 m (4.9 ft) long, 1 m (3.3 ft) wide, and 0.6 m (2 ft) deep. It was filled with leaf litter and modern soils (Figure 24). The troglophile meshweaver spider *Cicurina varians* was found in this feature. This feature was excavated on 10 August 2010 utilizing 0.8 person-hours of effort, resulting in the removal of 0.1 m^3 (3.5 ft^3) of material. A bedrock floor was reached at 0.7 m (2.3 ft) depth (Figure 25), with no mesocavernous voids leading off of the feature. The post-excavation dimensions of the feature were 1.5 m (4.9 ft) long, 1 m (3.3 ft) wide, and 0.7 m (2.3 ft) deep.

Figure 24. Overview of feature 281-014 prior to excavation.

Figure 25. Feature 281-014 after excavation, showing bedrock floor.

281-015, collapse sinkhole This depression is located on private property. It is 1.5 m (4.9 ft) long and 0.7 m (2.3 ft) wide, and was covered with trash when initially located on 2 March 2010 (Figure 26). It had soil and leaf litter infill that was loose to a depth of 0.2 m (0.7 ft). The troglophilic meshweaver *Cicurina varians* was found in this feature. Excavation was conducted on 10 August 2010 for one person-hour, resulting in the removal of 0.1 m^3 (3.5 ft^3) of material. A floor of hard-packed clay was reached at 0.25 m (0.8 ft) depth (Figure 27), with no mesocavernous voids extending from the feature. Post-excavation dimensions of the feature were 1.6 m (5.2 ft) long by 0.8 m (2.6 ft) wide by 0.25 m (0.8 ft) deep.


Figure 26. Overview of feature 281-015 prior to excavation.


Figure 27. Feature 281-015 after excavation, showing hard-packed clay floor.

281-016, enlarged fracture This feature is located in the east road cut of US 281 (Figure 28). When initially assessed on 2 March 2010, it had an opening 0.1 m (0.3 ft) in diameter, and it split into two routes with an estimated depth of over 1 m (3.3 ft) (Figure 29). Airflow was detected, suggesting a continuation; therefore excavation of the feature was conducted. On 18 June 2010, 5 person hours of excavation effort was expended utilizing an electric chipping hammer. One cubic meter (35 ft^3) of material was removed. The feature was enlarged to a width of 1.5 m (4.9 ft), with several large slabs still blocking the way. These were removed with a jackhammer on 21 June 2010 in an effort that involved 6 person hours of labor and the removal of an additional 1 m^3 (35 ft^3) of material (Figure 30). Post-excavation dimensions of the feature were 0.7 m (2.3 ft) long by 1.5 m (4.9 ft) wide by 1 m (3.3 ft) deep. Bedrock was reached, with no signs of a drain or karst processes. This feature was likely formed by fracturing caused by excavation of the road cut during road building activities. Excavation showed that the road cut extended below the current level of bar ditch fill.

Figure 28. Overview of feature 281-016, marked with flagging tape in the lower right side of picture. It was probably fracturing caused during excavation of the road cut.


Figure 29. View of feature 281-016 prior to excavation.

Figure 30. View of feature 281-016 after excavation. Bedrock can be seen on the right, and on the left is fill resulting from grading of the bar ditch.

281-017, solution cavity This feature is situated in the eastern road cut of US 281. It is a solution cavity with two small entrances that are approximately 0.1 m (0.5 ft) in diameter (Figure 31). It drops vertically into the road cut for approximately 0.5 m (1.6 ft). This feature was not recommended for excavation (Table 1).


Figure 31. View of feature 281-017.

281-018, man-made feature This is a water utility site that was recorded for purposes of the Geological Assessment, and is not karst related.

281-019, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-020, man-made feature When initially discovered, this feature was represented by nearly square shaped opening in the ground measuring 0.36 m (1.2 ft) by 0.33 m (1 ft) by

1.75 m (5.7 ft) deep (Figure 32). Photos of the interior of the feature revealed that is an abandoned hand-dug well or cistern (Figure 33). It is not karst related.

Figure 32. Overview of feature 281-020.

Figure 33. Interior of feature 281-020.

281-021, solutional sinkhole This was a solutional sinkhole that measured 0.5 m (1.6 ft) by 0.4 m (1.3 ft) across and was 0.8 m (2.6 ft) deep (Figure 34). It was in-filled with rocks and modern soils (Figure 35). It was recommended for excavation, but ROE for excavation purposes was not granted.


Figure 34. Feature 281-021 prior to brief exploratory excavation.


Figure 35. Feature 281-021 subsequent to removal of loose surface soil.

281-022, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-023, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-024, non-karst closed depression This was a depression measuring 1 m (3.3 ft) long and 0.7 m (2.3 ft) wide and 0.3 m (1 ft) deep (Figure 36). It was filled with leaf litter, modern soils, and trash. Two large rocks were removed from it during excavation on 13 August 2010. Post-excavation dimensions of this feature were unchanged. It was determined that his feature was formed by roots lifting rocks, and it is not karstic.

Figure 36. Overview of feature 281-024.

281-025, Taco Truck Tunnel, cave This is a cluster of closely spaced karst features, one of which is a cave. This cave is in a depression that measures 3 by 4 m (9.8 by 13.1 ft) across (Figure 37). One meter (3.3 ft) to the east of the cave is a solution hole that is 0.4 m (1.3 ft) in diameter. Three meters (10 ft) southeast of the cave is a solutionally-enlarged fracture that measures 0.76 by 0.91 m (2.3 by 2.5 ft), with a bearing of 137 degrees. Four meters (13 ft) to the southeast is a pair of fractures that form a cross 0.78 m (31 in) in diameter. These fractures have bearings of 77 and 167 degrees. The cave feature was recommended for excavation. Excavation took place on 13, 17, 19, 26, 27 August and 15-16 September 2010. Total excavation effort expended was 113 person hours, and 9.5 m^3 (335 ft^3) of soil and rocks was removed. The entrance to this cave is surrounded by sloping bedrock (Figure 38) measuring 1.8 by 1.2 m (5.9 by 3.9 ft) across. It drops 1.3 m (4.3 ft) to a ledge, followed by a 2.3 m (7.5 ft) climb-down to a dirt floor (Figure 39). A crawlway extends to the northwest for 1.5 m (4.9 ft), where the cave ends in a small dome (Figure 40). The post-excavation dimensions of the cave were 5 m (16.4 ft) long by 3.5 (11.5 ft) wide by 5 m (16.5 ft) deep. A lithic arrow point was found during soil excavations at this cave. The cave was named for a nearby dining establishment. Biological surveys on this feature were conducted on 17 and 24 September and 1 October 2010. A list of fauna encountered in 281-025 can be found in Table 6 and microclimate measurements are included in Table 7.

Table 6. Taxa encountered in feature 281-025.

Taxa	Order	Family	Species
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus cunicularis*
			Ceuthophilus secretus (adult, subadults)*
			Ceuthophilus sp. (nymph)*
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Millipedes	Spirostreptida	Cambalidae	*Cambala speobia* (**T**)
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Spiders	Araneae	Dictynidae	*Cicurina* sp.((immature)
Springtails	Collembola*	undetermined	

Taxa	Order	Family	Species
Snakes	Squamata	Colubridae	*Thamnophis* sp.*
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
Snails	Stylommatophora	Helicodiscidae	*Helicodiscus* sp.
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Cockroaches	Blattaria*	undetermined	
Mosquitoes	Diptera*	undetermined	
Moths	Lepidoptera*	undetermined	

*sight identification

Table 7. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-025.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
17 Sept	1618	Surface	25.7	33.0	969	56
17 Sept	-	In cave	26.4	27.7	969	90.3
24 Sept	0855	Surface	24.2	24.7	975	96
24 Sept	0910	In cave	24.5	25.5	975	92.2
1 Oct	0915	Surface	18	22	979	68
1 Oct	0910	In cave	19.5	21.0	979	87.2

Figure 37. Feature 281-025 prior to excavation.


Figure 38. Entrance to feature 281-025 after excavation.


Figure 39. Bottom of feature 281-025 after excavation.

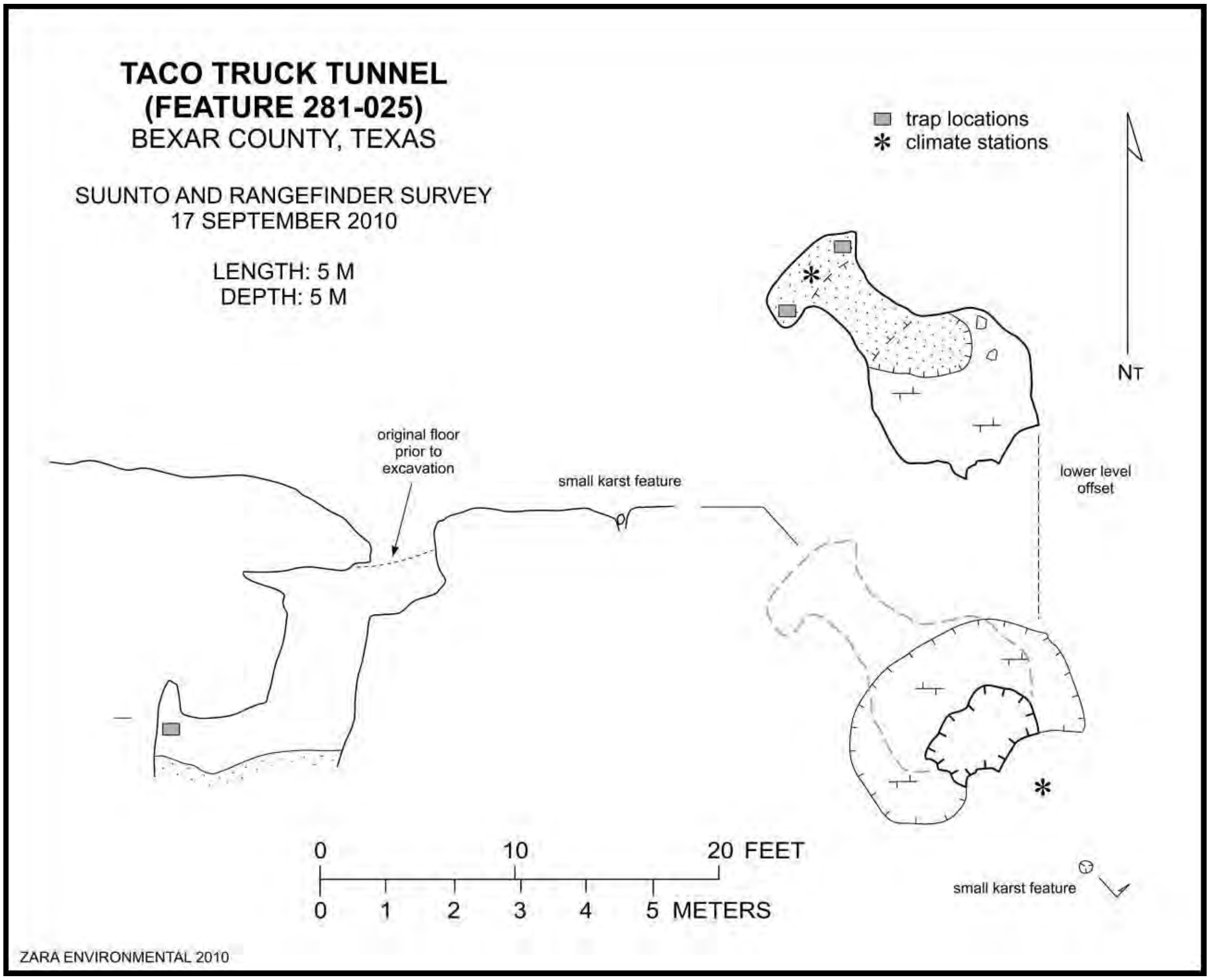

Figure 40. Map of feature 281-025.

281-026, solutional sinkhole This is a solutional sinkhole that was initially 1.3 m (4.3 ft) long and 1.2 m (3.9 ft) wide. It was 0.6 m (2 ft) deep and contained leaf litter and clean-washed rocks (Figure 41). The feature is formed along a fracture trending at 45 degrees. Excavation was conducted with hand tools on 19 August and with a jackhammer on 10 September 2010. A total of 5 person hours of effort was expended, resulting in the removal of 1.3 m^3 (46 ft^3) of material. A bedrock floor was reached at a depth of 0.5 m (1.6 ft) (Figure 42). Lateral excavation along a bedding plane for 0.5 m (1.6 ft) revealed nothing but hard-packed clay (Figure 43). Post-excavation dimensions of the feature were 1.3 m (4.3 ft) long and 1.25 m (4.1 ft) wide and 0.6 m (2 ft) deep. A list of fauna encountered in 281-026 can be found in Table 8.

Table 8. Taxa encountered in feature 281-026.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed, 1 female)
		Dictynidae	*Cicurina* undetermined (eyed: probably *varians*)
Millipedes	Julidia	Parajulidae	undetermined
Centipedes	Geophilomorpha	undetermined	

Figure 41. Overview of feature 281-026.

Figure 42. Overview of feature 281-026 after excavation.


Figure 43. Interior of feature 281-026 after excavation.

281-027, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-028, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-029, solutional sinkhole This is a depression that was initially 0.56 m (1.8 ft) long and 0.48 m (1.6 ft) wide (Figure 43). It had a noticeable drain, and contained fine infill comprised of leaf litter and black, modern soil (Figure 44). Excavation was conducted on 2 August 2010 resulted in the removal of a large rock and decaying sticks. A bottom of hard red clay was reached and no continuing drain could be seen. However, flood debris seen piled on top of the feature after a heavy rain indicates that it may have a high rate of infiltration. Post-excavation dimensions of this feature were 1 m (3.3 ft) in diameter with a depth of 0.3 m (1 ft).

Figure 44. Overview of feature 281-029.

Figure 45. Close-up view of feature 281-029.

281-030, sinkhole This is a depression of undetermined origin that contains old stumps, concrete, and rocks (Figure 46). It measures 0.5 by 0.25 m (1.6 by 0.8 ft), and is 0.2 m (0.7 ft) deep. Excavation was conducted on 2 August 2010, and 1 m^3 (35 ft^3)of material was removed utilizing hand tools. This material consisted of chunks of concrete and juniper stumps (Figure 47). The feature was excavated to a depth of 0.75 m (2.5 ft), about 0.2 m (0.7 ft) past the black soil layer into red and white clay. No drains were found. Post-excavation dimensions of this feature were 1.25 m (4.1 ft) in diameter and 0.75 m (2.5 ft) deep. Due to previous anthropogenic activity at this site, its origin is unclear.

Figure 46. Overview of feature 281-030 prior to excavation.

Figure 47. Feature 281-030 after excavation.

281-031, collapse sinkhole This pair of depressions within an area 3.5 m (11.5 ft) in length by 1 m (3.3 ft) wide (Figure 48 and Figure 49). They had coarse infill of modern soil and may be the result of tree removal. Excavation took place on 2 August 2010, and resulted in the removal of 0.4 m^3 (14 ft^3) of soil from the two depressions (Figure 50 and Figure 51). They were dug to depths of 0.3 and 0.4 m (1 and 1.3 ft) to hard packed bottoms with no drains. Post-excavation dimensions of the features were 1 m (3.3 ft) by 0.5 m (1.6 ft) by 0.4 m (1.3 ft) and 0.5 m (1.6 ft) in diameter by 0.3 m (1 ft) deep.


Figure 48. South depression at feature 281-031 prior to excavation.


Figure 49. North depression at feature 281-031 prior to excavation.


Figure 50. South depression at feature 281-031 after excavation.


Figure 51. North depression at feature 281-031 after excavation.

281-032, sinkhole This is a solutional or collapse sinkhole that is 1 m (3.3 ft) long and 0.8 m (2.6 m) wide (Figure 52). It receives recharge from an area measuring 3 by 5 m (9.8 by 16.4 ft). It contained infill of leaf litter and clean-washed rocks. An opossum was observed in this feature. Excavation was conducted on 2 August 2010. Black soil and rocks were removed from the floor, reaching a hard-packed bottom with no drains at a depth of 0.9 m (2.9 ft) (Figure 53). Post-excavation dimensions of the feature were 1 m (3.3 ft) in diameter and 0.9 m (2.9 ft) deep.

Figure 52. Feature 281-032 prior to excavation.

Figure 53. Feature 281-032 after excavation.

281-033, water well This feature is a well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-034, water well This feature is a well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-035, non-karst closed depressions This is a cluster of three depressions on private property at the northwest corner of Overlook Parkway and US 281 (Figure 54). When initially assessed, their origin was not clear. Excavation took place on 19 August 2010 for 1 person-hour, resulting in the removal of 0.25 m^3 (8.8 ft^3) of material. Excavation reached hard-packed soil at a depth of 0.35 m (1.1 ft). This feature is likely the result of tree-clearing, not karst processes (Figure 55). Post-excavation dimensions of the largest feature were 1.5 m (4.9 ft) in diameter and 0.35 m (1.1 ft) deep.

Figure 54. Feature 281-035 prior to excavation.

Figure 55. Feature 281-035 after excavation, showing hard-packed dirt floor.

281-036, non-karst closed depression This is a depression located on private property at the northwest corner of Overlook Parkway and US 281. When initially examined, it had a diameter of 1.2 m (3.9 ft) and a depth of 0.5 m (1.6 ft) (Figure 56). It was recommended for excavation, which took place on 19 August 2010. This excavation utilized 1.4 person-hours of effort, and resulted in the removal of 0.1 m^3 of material. A bedrock floor was reached with no mesocavernous voids extending from the feature (Figure 57). Post-excavation dimensions of the feature were 1.5 m (4.9 ft) in diameter and 0.75 m (2.5 ft) deep. This feature is likely the result of tree-clearing, not karst processes.


Figure 56. Feature 281-036 prior to excavation.


Figure 57. Feature 281-036 after excavation, showing bedrock floor.

281-037, Painful Crawl, cave This is an enlarged bedding plane cave in a road cut associated with a parking lot outside of the ROW. It was partially filled with concrete, but a low passage could be seen extending into the road cut (Figure 58). Excavation was conducted on 15-16 September 2010. This resulted in 2 m^3 (106 ft^3) of rocks being removed from the cave using 20 person hours of effort with hand and power tools. This cave is developed in a low, wide bedding plane, and is just tall enough for human entry (Figure 59). The bedrock and flowstone floor is rough, giving rise to the name Painful Crawl (Figure 60). Excavation concentrated on removing bits of rock from the floor and ceiling in order to be able to enter the passage, but did not change the existing footprint of the cave. Excavation continued 10 m (32.8 ft) until dark zone habitat was reached. The entrance to Painful Crawl is at the bottom of a sloping road cut that is 3.5 m tall. It is 1.4 m (4.6 ft) wide and 0.4 m (1.3 ft) tall. After 3 m (9.8 ft), the passage takes a turn to the east, with small bedding plane openings also extending off to the south and west at this turn. After another 4 m (13 ft), a junction is reached. A dig lead to the north appears that it would connect back to the road cut if excavated. A dig lead also extends to the east. The main passage continues to the south for 3 m (9.8 ft) before it gets too low for human entry (Figure 61). Post-excavation dimensions of the cave were 10 m (32.8 ft) long by 5 m (16.4 ft) wide by 0.7 m (2.3 ft) deep. Biological surveys on this feature were conducted on 17 and 24 September and 1 October 2010. A list of fauna encountered in 281-037 can be found in Table 9 and microclimate measurements are included in Table 10.

Table 9. Taxa encountered in feature 281-037.

Taxa	Order	Family	Species
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymph)*
Field Crickets	Orthoptera	Gryllidae*	
Harvestmen	Opiliones*	undetermined	
	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Spiders	Araneae	undetermined	
		Dictynidae	*Cicurina* (eyed: probably *varians*)*
			Cicurina undetermined
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Springtails	Collembola*	undetermined	
Earwig-like Diplurans	Diplura	Campodeidae	
Assassin Bugs	Hemiptera	Reduviidae	
Isopods	Isopoda	Porcellionidae	*Porcellio* sp.
Lampreys	Petromyzoniformes*	undetermined	
Frogs	Anura	Leptodactylidae*	
Gastropods	Stylommatophora	Helicodiscidae	*Helicodiscus* sp.*
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Cockroaches	Blattaria*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 10. Dates of biological surveys and in-cave temperature and humidity measurements at Feature 281-037.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
17 Sept	1340	Surface	27.0	31.5	972	70.6
17 Sept	1350	In cave	27.0	29.0	972	85.7
24 Sept	1200	Surface	25.4	28.3	977	79.3
24 Sept	1218	In cave	26.5	28.0	977	88.9
1 Oct	1033	Surface	23.7	24.5	974	93.6
1 Oct	1040	In cave	23.5	23.8	974	97.5


Figure 58. Feature 281-037, which was partially filled with concrete.


Figure 59. Entrance to feature 281-037 after enlargement by excavation.

Figure 60. Interior of feature 281-037.

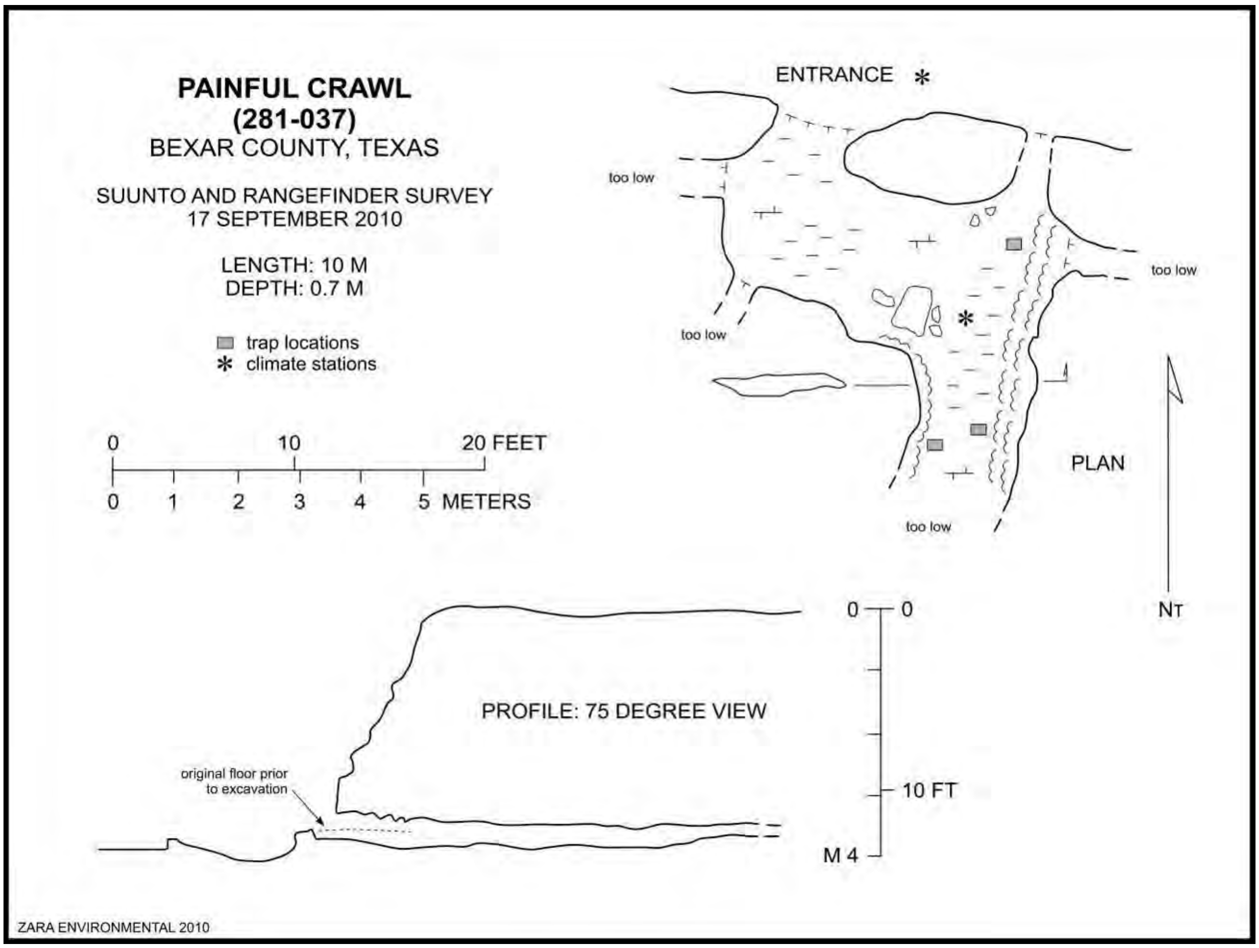

Figure 61. Map of feature 281-037.

281-038, solutional sinkhole This is a solutional sinkhole that is 2.3 m (7.5 ft) long, 1 m (3.3 ft) wide, and 0.4 m (1.3 ft) deep. It consists of two holes draining under a bedrock shelf with infill of leaf litter and modern soil that is loose to a depth of 0.2 m (0.7 ft) (Figure 62). Excavation was recommended, but ROE for excavation purposes was not granted.

Figure 62. Overview of feature 281-038.

281-039, non-karst closed depression This feature is located on private property on the west side of US 281. When initially located it was a depression 0.25 m (0.8 ft) in diameter and 0.13 m (0.4 ft) deep, with a coarse infill of rocks and modern soils (Figure 63). Excavation was conducted on 10 September 2010. This utilized 0.6 person-hours of effort and removed 0.1 m^3 (3.5 ft^3) of material. Post-excavation dimensions of this feature were 1.5 m (4.9 ft) long by 0.75 m (2.5 ft) wide by 0.5 m (1.6 ft) deep. This feature is located in a landfill deposit, and is a result of poor consolidation (Figure 64). It is not a karst feature.

Figure 63. Feature 281-039 prior to excavation.

Figure 64. Feature 281-039 after excavation, showing landfill rocks.

281-040, non-karst closed depression This feature is located on private property on the west side of US 281. When initially located, it was 1.3 m (4.3 ft) in diameter and 0.3 m (1 ft) deep (Figure 65). It had infill of leaf litter and black, modern soil. Excavation was conducted on 10 September 2010, utilizing 1 person-hour of effort and removing 0.2 m^3 (7 ft^3) of rocks and soil to a bedrock floor (Figure 66). Post-excavation dimensions of this feature were 1.4 m (4.6 ft) in diameter and 0.6 m (2 ft) deep. This feature is erosional in origin, likely the result of bedding plane slumping on a hillside slope.


Figure 65. Feature 281-040 prior to excavation.


Figure 66. Feature 281-040 after excavation.

281-041, enlarged fracture This solutionally-enlarged fracture is located on private property on the west side of US 281. Prior to excavation, it measured 0.8 m (2.6 ft) in length by 0.1 m (0.3 ft) in width, and was 0.3 m deep (Figure 67). It contained fine, black sediment of modern origin. Excavation was conducted with a jackhammer on 10 September 2010 utilizing 2 person-hours of effort and removing 0.3 m^3 (10.6 ft^3) of material. The excavation reached a bedrock floor at a depth of 0.6 m (2 ft), with no mesocavernous voids extending off of it (Figure 68). Post-excavation dimensions of the feature were 1.25 m (4.1 ft) long by 0.75 m (2.5 ft) wide by 0.6 m (2 ft) deep.


Figure 67. Feature 281-041 prior to excavation.


Figure 68. Bedrock floor of feature 281-041 after excavation.

281-042, non-karst closed depression/animal burrow This feature is located on private property on the west side of US 281. When initially assessed, it consisted of two depressions within an area measuring 1 by 2 m (3.3 by 6.6 ft) (Figure 69). It had infill of leaf litter and modern soil that was loose to a depth of 15 cm (0.5 ft). Excavation was conducted on 10 September 2010. This effort utilized 1 person-hour of effort and removed 0.1 m^3 (3.5 ft^3) of material. Post-excavation dimensions of the largest feature were 0.75 m (2.5 ft) in diameter and 0.3 m (1 ft) deep. This feature is an old, filled animal burrow that goes under a slab of limestone and exits the other side (Figure 70). It is not a karst feature.


Figure 69. Feature 281-042 prior to excavation.


Figure 70. Feature 281-042 after excavation.

281-043, non-karst closed depression/animal burrow This depression was 2 m (6.6 ft) in diameter and 1 m (3.3 ft) deep when initially assessed (Figure 71). It had fine infill of leaf litter and black, modern soil. Excavation was conducted on 3 August 2010; 1 m^3 (35 ft^3) of dirt and leaves was removed from the feature. Post-excavation dimensions of the feature were 2 m (6.6 ft) long by 2.5 m (8.2 ft) wide by 1 m (3.3 ft) deep. The floor was hard-packed red clay, with an animal burrow at the south end of the feature (Figure 72). Construction activities on this ROE site later resulted in the area being graded over.

Figure 71. Feature 281-043 prior to excavation.

Figure 72. Feature 281-043 after excavation.

281-044, solutional sinkhole When initially assessed, this solutional sinkhole was 2.5 m (8.2 ft) long, 1.25 m (4.1 ft) wide, and 1.2 m (3.9 ft) deep (Figure 73). It contained infill composed of leaf litter and modern, black soil that was loose to a depth of 20 cm. It is recharged by sheet-wash from an area measuring 30 by 30 m (98 by 98 ft). Excavation on 3 August 2010 removed 2.5 m^3 (88 ft^3) of loose soil and rocks, deepening the feature to 1.8 m (5.9 ft) (Figure 74). Post-excavation dimensions of this feature were 2.5 m (8.2 ft) long, 1.25 m (4.1 ft) wide, and 1.8 m (5.9 ft) deep. At that point ROE for excavation was revoked, preventing further excavation that would likely have led to a cave. The feature was backfilled.


Figure 73. Feature 281-044 prior to excavation.


Figure 74. Feature 281-044 during excavation.

281-045, cave This feature is located in drainage, and consists of two low, enlarged bedding planes that cut back under the drainage (Figure 75 and Figure 77). Flood waters cascading down over the top of these entrances has caused scour, piling up gravel and rocks just downstream. The westernmost of the two entrances extends in for 3 m (9.8 ft) to a bedrock terminus (Figure 76). The eastern entrance extends 4 m (13.1 ft) and also terminates in bedrock (Figure 78). Excavation was conducted on 4, 19, and 25 August to enlarge these bedding plane openings for biological evaluation. Using hand and power tools, 2 m^3 (71 ft^3) of material was removed with 25.5 person hours of effort. The cave was mapped during a subsequent visit (Figure 79).Post-excavation dimensions of this feature were 7 m (23 ft) long, 4 m (13.1 ft) wide and 0.7 m (2.3 ft) deep.

Biological surveys on this feature were conducted on 1, 12, and 24 September 2010. A complete list of fauna encountered in 281-045 can be found in Table 11 and microclimate measurements are included in Table 12.

Table 11. Taxa encountered in feature 281-045.

Taxa	Order	Family	Species
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus secretus* (juvenile)*
Field Crickets	Orthoptera	Gryllidae (nymphs)*	
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Spiders	Araneae*	undetermined	
		Dictynidae	*Cicurina* sp. (immature)
Springtails	Collembola*	undetermined	
Ground Beetles	Coleoptera	Carabidae	
Assassin Bugs	Hemiptera	Reduviidae*	
Isopods	Isopoda	Porcellionidae	*Porcellio* sp.*
		Oniscoidea	(1 eyed – could not be keyed due to size)
		Armadillidiidae	*Armadillidium vulgare**
Centipedes	Scolopendromorpha*	undetermined	
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Gnats and Mosquitoes	Diptera*	undetermined	
Mice	Rodentia*	undetermined	

*sight identification

Table 12. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-045.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
1 Sept	-	-	-	-	-	-
9 Sept	1346	Surface	25.8	31.2	970	65.2
9 Sept	1349	In cave	25.5	27.5	970	85.3
12 Sept	1221	Surface	27	33.5	978	60.5
12 Sept	1230	In cave	28.0	31.0	978	79.7
24 Sept	0942	Surface	24.8	26.5	975	87.1
24 Sept	0958	In cave	25.7	26.3	975	95.3
24 Sept	1000	In cave	26.0	26.5	975	96.1

Figure 75. Entrance to the western portion of feature 281-045.

Figure 76. Terminus of the western portion of feature 281-045 after excavation.


Figure 77. Entrance to the eastern portion of feature 281-045.


Figure 78. Terminus of the eastern portion of feature 281-045 after excavation.

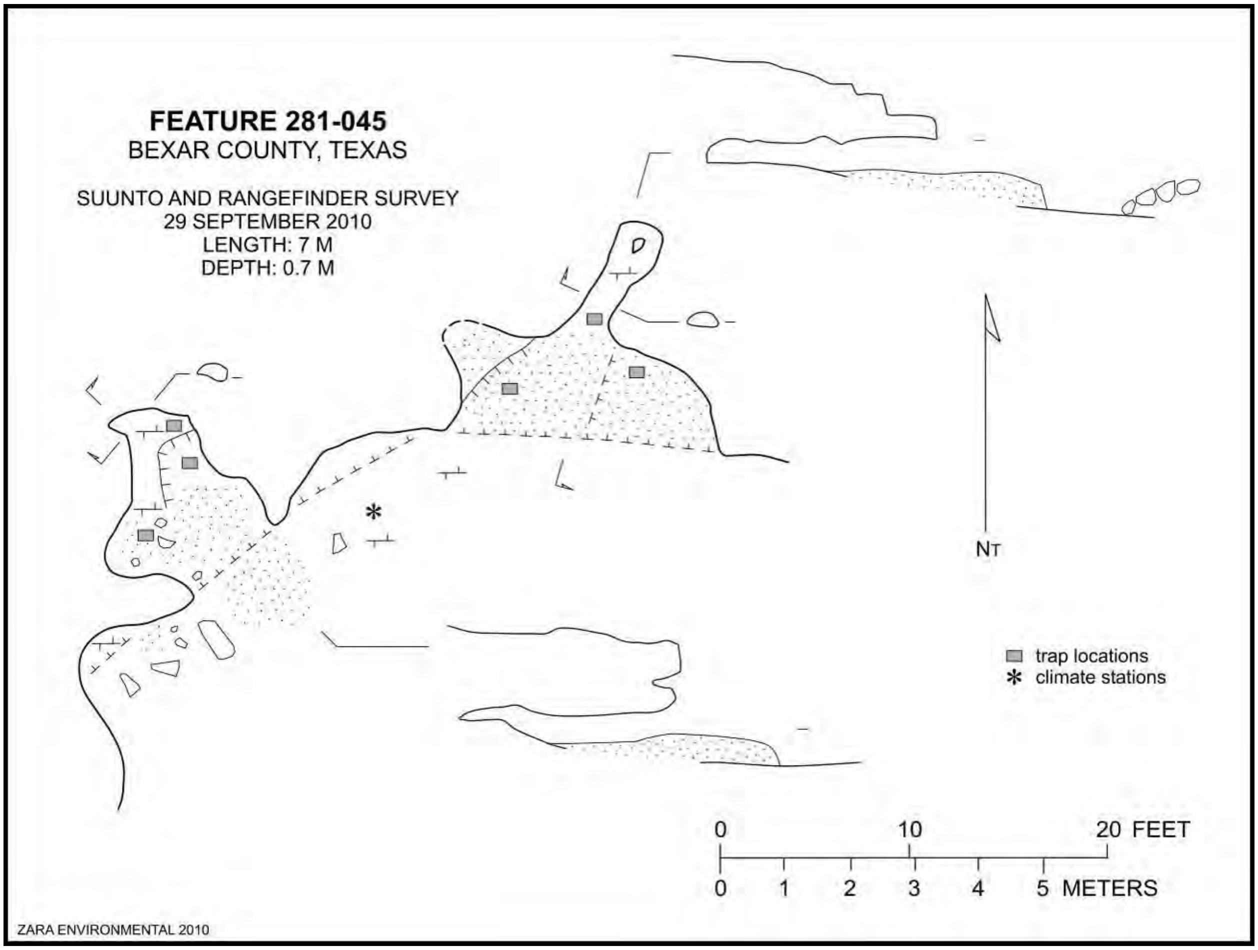

Figure 79. Map of feature 281-045.

281-046, non-karst closed depression/animal burrow When initially assessed, this feature was a depression 0.3 m (1 ft) in diameter containing roots and water (Figure 80). It had infill of leaf litter and modern, black soil. Excavation conducted on 4 August 2010 removed some soil, and revealed an animal burrow. Post-excavation dimensions of the feature were 1 m (3.3 ft) in diameter by 0.5 m (1.6 ft) deep (Figure 81). It is not a karst feature.


Figure 80. Feature 281-046 prior to excavation.


Figure 81. Feature 281-046 after excavation.

281-047, solutional sinkhole When initially assessed, this feature was 1.5 m (4.9 ft) long, 1 m (3.3 ft) wide, and 0.4 m (1.3 ft) deep (Figure 82). It contained fine black sediment of modern soil and leaf litter. It was excavated on 3 August 2010 to a solid bedrock floor (Figure 83).


Figure 82. Feature 281-047 prior to excavation.


Figure 83. Feature 281-047 after excavation.

281-048, solutional sinkhole This solutional sinkhole was 3 m (9.8 ft) long and 1 m (3.3 ft) wide and 2 m (6.6 ft) deep (Figure 84) and contained fine infill of black, modern soil and leaf litter (Figure 85). Airflow was detected in the feature on 12 March 2010. It was recommended for excavation, but ROE for excavation purposes was denied.

Figure 84. Overview of feature 281-048.

Figure 85. Interior of feature 281-048.

281-049, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-050, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not considered a karst feature.

281-051, enlarged fractures This is a set of enlarged cross-fractures located on private property. The feature was 2.5 m (8.2 ft) long, 0.2 m (0.7 ft) wide, and 0.3 m (1 ft) deep. The main fracture trends at approximately 90 degrees, with several minor fractures crossing at 45 degrees (Figure 86). It receives sheet-wash drainage from an area measuring 20 by

30 m (66 by 98 ft). It has infill of black, modern soil and leaf litter that is loose to a depth of 0.3 m (1 ft). It was recommended for excavation, but ROE for excavation purposes was not obtained.


Figure 86. Overview of feature 281-051.

281-052, non-karst closed depression This feature is located on the west side of US 281 on private property. It is a 10 m-diameter (32.8 ft) depression with a depth of 1.5 m (4.9 ft) (Figure 87) formed by the introduction of landfill material on its north side and not by karst processes. This feature was not recommended for excavation (Table 1).


Figure 87. Overview of feature 281-052.

281-053, non-karst closed depression It is located on the west side of US 281 on private property. It is composed of three openings within an area that is 3 m (9.8 ft) long, 0.6 m (2 ft) wide, and 1 m (3.3 ft) deep (Figure 88). This feature is located in the same landfill deposit as feature 281-052. It was recommended for excavation, but when excavation commenced on 10 September 2010, it was immediately determined to be non-karstic. It is formed in a landfill deposit, and is a result of collapse or piping into loose fill.


Figure 88. Overview of feature 281-053.

281-054, solution cavity/enlarged bedding plane This feature is an enlarged bedding plane at the base of a road cut on private property on the east side of US 281 (Figure 89). This opening is 8 m (26.2 ft) wide, 0.3 m (1 ft) tall, and extends at least 0.6 m (2 ft) into the cut (Figure 90).


Figure 89. Overview of feature 281-054.


Figure 90. Interior of feature 281-054.

281-055, solution cavity/enlarged bedding plane This feature is an enlarged bedding plane at the base of a construction site road cut on private property. It is 2 m (6.6 ft) wide, 1.7 m (5.6 ft) tall, and extends into the road cut for 1 m (3.3 ft) (Figure 91). It is developed along a fracture bearing 90 degrees. It was recommended for excavation, but ROE for excavation purposes was not granted.

Figure 91. Overview of feature 281-055.

281-056, non-karst closed depression/animal burrow This feature is located on the east side of 281, in the north flood plain of Mud Creek. When initially assessed, it was a depression in soil 1 m (3.3 ft) in diameter and 0.5 m (1.6 ft) deep (Figure 92). Excavation was conducted at this feature on 20 May 2010 by two persons for 50 minutes. Approximately 0.05 m^3 (1.8 ft^3) of fill was removed from the feature to reveal an animal burrow (Figure 93). Post-excavation dimensions of this feature were 1 m (3.3 ft) in diameter by 0.75 m (2.5 ft) deep. The only fauna encountered in this feature were a surface centipede in the order Scutigeromorpha (family Scutigeridae) and a rattlesnake (*Crotalus atrox*).


Figure 92. Feature 281-056 prior to excavation.


Figure 93. Feature 281-056 after excavation. It is an animal burrow.

281-057, solutional sinkhole This feature consisted of a depression that was 1.5 m (4.9 ft) in diameter and 0.4 m (1.3 ft) deep (Figure 94). It had a large rock on its south side, and was filled with fine black sediment and leaf litter that was loose to a depth of 0.3 m (1 ft). There was a small tree with some exposed growing from the feature. The feature receives sheet wash flow from an area measuring 25 by 30 m (82 by 98 ft). It was recommended for excavation; however ROE was rescinded prior to the initiation of excavation activities.


Figure 94. Overview of feature 281-057.

281-058, sinkhole This is potentially a collapse or solutional sinkhole that is 3.5 m (11.5 ft) in diameter and 0.7 m (2.3 ft) deep. It is filled with soil and has two live oak trees growing out of it (Figure 95). It was recommended for excavation in order to determine its origin; however, ROE was rescinded prior to the initiation of excavation activities.


Figure 95. Overview of feature 281-058.

281-059, non-karst closed depression This depression is 5 m (16.4 ft) long, 3 m (9.8 ft) wide and 0.5 m (1.6 ft), and is surrounded by a curbed parking lot. There are two oak trees within it (Figure 96). It was most likely formed by the area surrounding it being built up for the parking lot, with the area around the trees left unfilled so that the trees would not die. It is a non-karst closed depression. This feature was not recommended for excavation (Table 1).

Figure 96. Overview of feature 281-059.

281-060, solution cavity/enlarged bedding plane This is an enlarged bedding plane opening in a road cut on the west side of US 281. It consists of three side by side openings within an area 2.25 m (7.4 ft) wide (Figure 97). They are 0.3 m (1 ft) tall and extend no more than 0.5 m (1.6 ft) into the road cut (Figure 98). This feature was not recommended for excavation (Table 1).

Figure 97. Overview of feature 281-060.

Figure 98. Interior of feature 281-060.

281-061, enlarged fracture This feature is an enlarged fracture developed along a trend of 90 degrees in a road cut on the west side of US 281. It is 0.4 m (1.3 ft) wide, 0.9 m (2.9 ft) tall, and extends into the road cut for 1.25 m (4.1 ft). No image is available for this feature. This feature was not recommended for excavation (Table 1).

281-062, cave This enlarged bedding plane in the road cut on the west side of US 281 had a 1.9 m wide and 0.75 m high entrance (Figure 99), and extended 2 m (6.6 ft)into the road cut. Excavation was conducted on 3 June 2010, when 3 m^3 of material was removed. These rocks were lightly cemented together with calcite, with voids between them. The excavation trended back underneath the roadway with an unstable ceiling, and excavation efforts ceased about 5 m into the feature (Figure 99). Post-excavation dimensions of the cave were 5.4 m long (17.7 ft) by 1.5 m (4.9 ft) wide and 3.4 m (11.1 ft) deep (Figure 101).

Biological surveys on this feature were conducted on 14, 21, and 29 June, and 12 September 2010. A complete list of fauna encountered in feature 281-062 is included in Table 13 and microclimate measurements are included in Table 14.

Table 13. Taxa encountered in feature 281-062.

Taxa	Order	Family	Species
Harvestmen	Opiliones	undetermined	
		Stygnopsidae	*Chinquipellobunus* sp. (**T**)
Spiders	Araneae	undetermined	
Millipedes	Spirostreptida	Cambalidae	*Cambala speobia* (**T**)
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
Centipedes	Scolopendromorpha	Scolopendridae	*Scolopendra* sp.*
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Mice	Rodentia*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 14. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-062. Pressure on 14 June 2010 obtained from weather underground-Encino Park, The Ridge.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
14 June	1025	Surface	24.8	29.5	1010	68.1
14 June	1105	In cave	25.2	25.8	1010	95.3
21 June	1510	Surface	25.5	34.5	977	48.7
21 June	1523	In cave	25.7	26.4	977	94.6
29 June	1016	Surface	26.2	30.1	976	73.6
29 June	1020	In cave	26	27	976	92.4

Figure 99. Overview of feature 281-062.


Figure 100. Interior of feature 281-062.

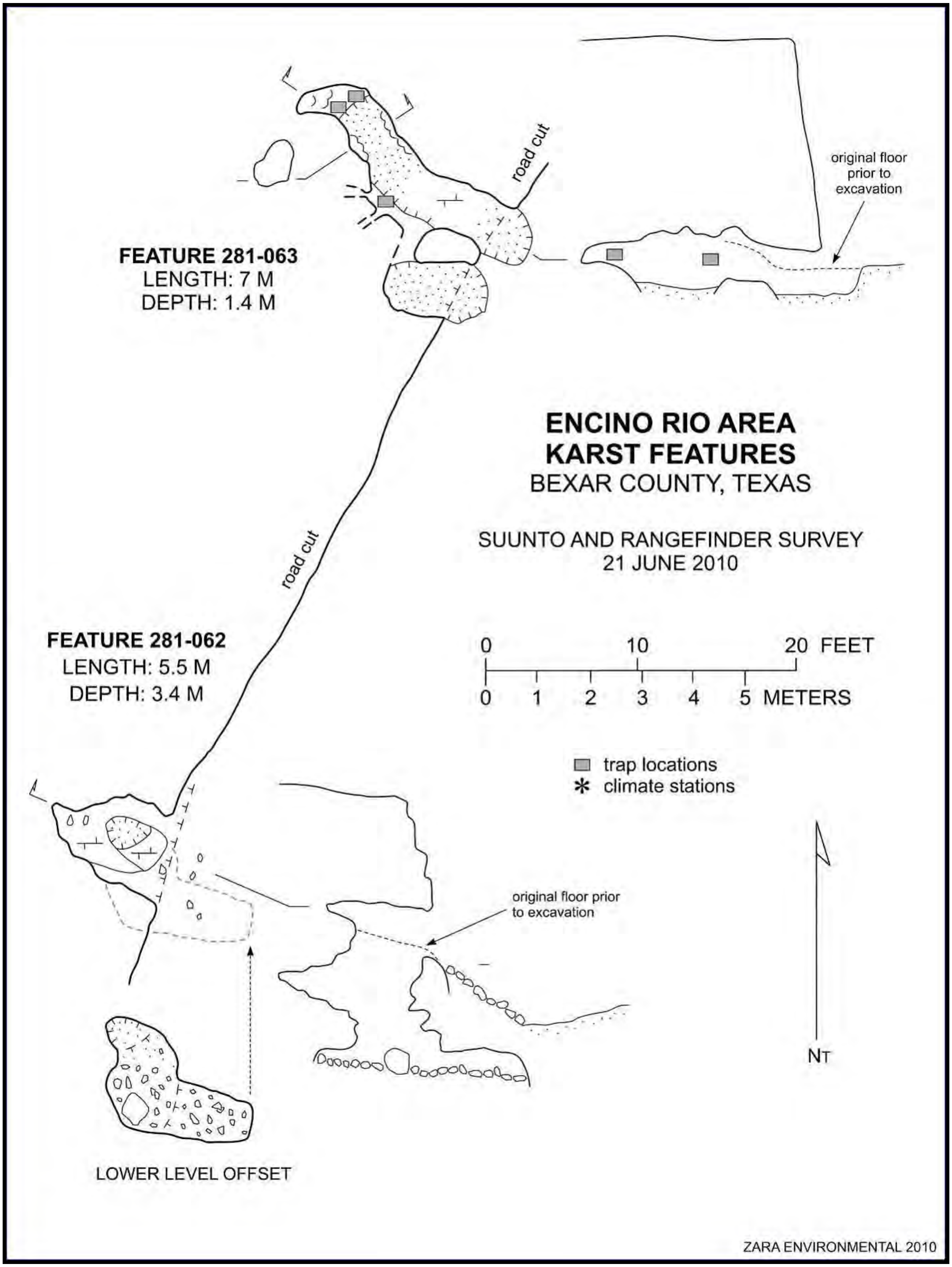

Figure 101. Map of features 281-062 and 281-063.

281-063, cave This feature is in the road cut on the west side of US 281, south of Encino Rio. It has two entrances at the base of the road cut that were initially 0.5 m (1.6 ft) wide (Figure 102).The northern entrance could be seen to extend 2 m into the road cut and continued on. It contained infill of leaf litter and modern soils. It was excavated on 3, 14, and 23 June 2010 (Figure 103). These excavations resulted in the removal of 3 m^3 (106 ft^3) of material from the feature. The resulting cave is 7 m (23 ft) long; with a small connection between the two entrances that is not passable (Figure 101). Each entrance is 1 m (3.3 ft) wide and both passages drop below the level of the roadway shoulder to a depth of 1.4 m (4.6 ft). The south entrance quickly rejoins the main passage in the north section. The cave ends in a flowstone wall. Biological surveys on this feature were conducted on 25 June, and 1, 9, 12, and 24 September 2010. A complete list of fauna encountered in 281-063 is included in Table 15 and microclimate measurements are included as Table 16.

Table 15. Taxa encountered in feature 281-063.

Taxa	Order	Family	Species
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi*
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. *(**T**)
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
		Porcellionidae	*Porcellio* sp.*
		Armadillidiidae	*Armadillidium vulgare**
Springtails	Collembola*		
Earwig-like Diplurans	Diplura	Campodeidae	
Flies and Gnats	Diptera*	undetermined	
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Cockroaches	Blattaria*	undetermined	
Mites	Acari*	undetermined	
Termites	Isoptera*	undetermined	
Earwigs	Dermaptera*	undetermined	
Frogs	Anura*	undetermined	
		Leptodactylidae	*Eleutherodactylus marnockii**
Geckos	Squamata*	undetermined	
Earthworms	Haplotaxida	undetermined	

*sight identification; (**T**) indicates troglobite

Table 16. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-063.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
25 June	1438	Surface	25.3	35.3	973	44.8
25 June	1445	In cave	25.4	26.0	973	95.3
1 Sept	-	-	-	-	-	-
9 Sept	1434	Surface	27.5	32.7	973	67.2
9 Sept	1443	In cave	27.5	27.7	973	98.5
12 Sept	1246	Surface	26.5	35.5	981	49.4
12 Sept	1218	In cave	28.5	31.0	981	82.9
24 Sept	1018	Surface	26.8	30.6	981	74.4
24 Sept	1025	In cave	28.0	29.0	981	92.7


Figure 102. Entrances to feature 281-063.


Figure 103. Interior of feature 281-063.

281-064, non karst closed depression This is a depression at the base of the road cut on the west side of US 281. When initially assessed it was 2 m (6.5 ft) in diameter and 0.3 m (1 ft) deep (Figure 104). It had fine infill of leaf litter and modern soils. It receives sheetwash from a drainage area of 600 m^2 (6,458 ft^2) from the bar ditch. It was excavated on 14 June 2010; 0.05 m^3 (1.8 ft^3) of material was removed with 2 person hours of labor. Post-excavation dimensions of the feature were 2 m (6.5 ft) in diameter and 1.25 m (4.1 ft) deep. Excavation reached a bedrock bottom with an apparent drain hole. However, this hole is actually a drill hole from the original road cut construction (Figure 105), not part of a karst feature.

Figure 104. Feature 281-064 prior to excavation.

Figure 105. Feature 281-064 after excavation, with drill hole visible.

281-065, enlarged fracture This is an enlarged fracture in the road cut on the west side of US 281 that had an opening 0.5 m (1.6 ft) wide and 1 m (3.3 ft) high (Figure 106). It dropped downward at least 0.5 m (1.6 ft). It was excavated on 17, 21, and 23 June 2010 for 17 person hours, removing 1.25 m^3 (44 ft^3) of hard rock with jackhammers. After to a depth of 1 m (3.3 ft), no voids could be seen extending from the feature (Figure 107). Post-excavation dimensions of the feature were 1 m (3.3 ft) in length by 1 m (3.3 ft) in width by 1 m (3.3 ft) in depth.

Figure 106. Feature 281-065 during excavation, showing solutionally-enlarged fracture.

Figure 107. Feature 281-065 after excavation.

281-066, enlarged fracture This feature is located in the road cut on the west side of US 281. It is an enlarged fracture/bedding plane trending at 90 degrees that is 0.5 m (1.6 ft) wide, 0.25 m (0.8 ft) tall (Figure 108), and it extends into the road cut for 1.25 m (4.1 ft) (Figure 109). This feature was not recommended for excavation (Table 1).


Figure 108. Overview of feature 281-066.


Figure 109. Interior of feature 281-066.

281-067, collapse sinkhole This feature appears to be a collapse sinkhole (Figure 110). It is 1 m (3.3 ft) in diameter and 0.3 m (1 ft) deep, with infill composed of black, modern soil, leaf litter, and rocks. It was recommended for excavation, but ROE for that purpose was denied.


Figure 110. Overview of feature 281-067.

281-068, water well This feature is a water well that was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-069, solution cavity/enlarged bedding plane This enlarged bedding plane is located in the road cut on the east side of US 281 (Figure 111). It is 1.5 m (4.9 ft) wide, 0.5 m (1.6 ft) tall, and extends into the road cut for 1.5 m (4.9 ft). It has a coarse infill of rocks (Figure 112). This feature was not recommended for excavation (Table 1).


Figure 111. Overview of feature 281-069.


Figure 112. Interior of feature 281-069.

281-070, Stafford Cave This feature is located in the east road cut of US 281. It is an enlarged bedding plane that had an entrance 0.4 m (1.3 ft) in diameter (Figure 113), and it could be seen to extend 1.5 m (4.9 ft) into the road cut with a small opening continuing on. Slight airflow was detected. It was excavated on 16-17 June 2010. Fourteen person-hours of effort were utilized to remove rocks in order to make the crawlway passable (Figure 114). The cave can be entered for 9 m (29.5 ft) before it becomes too low to pass (Figure 115). The post-excavation width was 2 m (6.6 ft) and the depth was 1 m (3.3 ft). The cave was named for the brand of an article of clothing found in the entrance. A map of the cave and other nearby features is presented in Figure 116. Biological surveys on this feature were conducted on 18 and 25 June, and 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-070 is included in Table 17 and microclimate measurements are included as Table 18. Stafford Cave is developed in the same bedding plane as numerous other caves and karst features on both sides of US 281 just south of Marshall Road. This area has the greatest density of documented caves within the study area (Figure 117).

Table 17. Taxa encountered in feature 281-070.

Taxa	Order	Family	Species
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus cunicularis**
			*Ceuthophilus secretus**
			Ceuthophilus sp. (nymph)*
Field Crickets	Orthoptera	Gryllidae (nymphs)*	
Harvestmen	Opiliones	Phalangodidae	*Texella ?tuberculata*# (**T**)
Springtails	Collembola*	Entomobryidae	*Pseudosinella violenta**
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Spiders	Araneae	Dictynidae	*Cicurina* (eyed: probably *varians*)
		Nesticidae	*Eidmannella* sp.*
	Araneae*	undetermined	(blind, immature)
Mites	Acari	undetermined	
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Millipedes	Spirostreptida*	undetermined	
Ants	Hymenoptera	Formicidae*	
Moths	Lepidoptera*	undetermined	
Gnats	Diptera*	undetermined	
Cockroaches	Blattaria*	undetermined	
Snails	Gastropoda*	undetermined	
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
	Anura*	undetermined	

*sight identification; (**T**) indicates troglobite; #See Appendix G for taxonomic verification

Table 18. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-070.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
18 June	-	-	-	-	-	-
25 June	1209	Surface	25	31.6	974	58.7
25 June	1212	In cave	24.5	25.3	974	93.7
25 June	1224	In cave	24.3	24.6	974	97.6
1 Sept	-	-	-	-	-	-
9 Sept	1017	Surface	25	28	975	78.5
9 Sept	1100	In cave	24	25	969	92.1
16 Sept	1351	Surface	26.5	30.5	970	73.2
16 Sept	1403	In cave	27.5	29.5	970	85.8
1 Oct	1157	In cave	24.2	24.4	976	98.4

Figure 113. Overview of feature 281-070.

Figure 114. Entrance to feature 281-070 after excavation.


Figure 115. Interior of feature 281-070 after excavation.

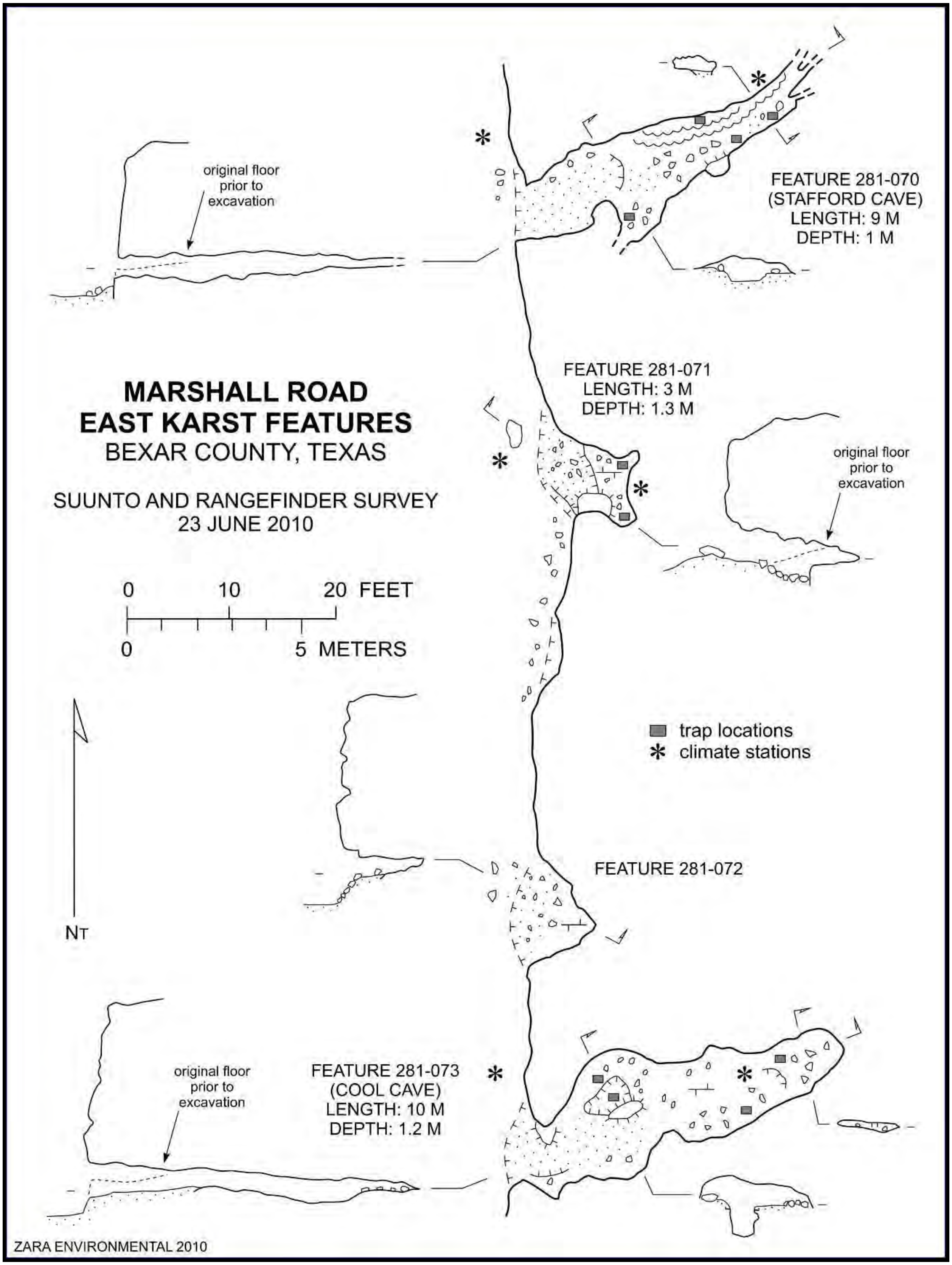

Figure 116. Map of features 281-070 through 281-073.

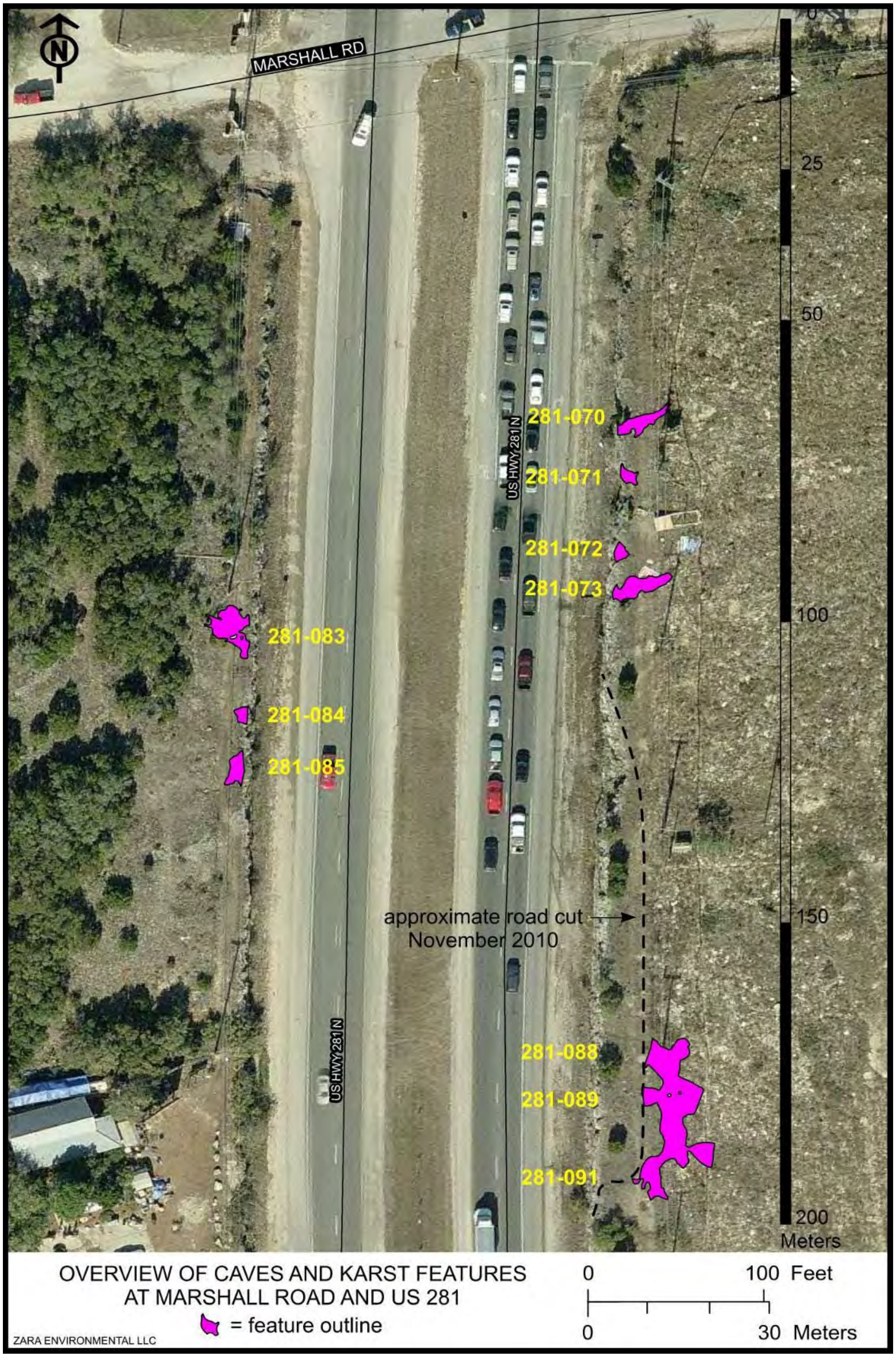

Figure 117. Overview of caves and karst features south of Marshall Road.

281-071, solution cavity/enlarged bedding plane This feature is located in the east road cut of US 281. It is an enlarged bedding plane with an entrance that is 2 m (6.6 ft) wide and 1 m (3.3 ft) high (Figure 118). It extended for 3 m (9.8 ft) into the road cut, with a small hole continuing on (Figure 119). Previous excavation has occurred here, as evidenced by a tailings pile just outside of the entrance. It was excavated on 16 June 2010. About 1 m^3 (35 ft^3) of rock was removed from the back of the feature, which was a bedding plane shelf with small openings continuing on (Figure 120). Further excavation effort would have required intense bedrock mining. Given that it was developed in the same bedding plane as the sample-able habitat in Stafford Cave and Cool Cave on either side of it, further excavation efforts were not deemed worthwhile. The post-excavation dimension were 3 m (9.8 ft) long by 2 m (6.6 ft) wide bay 1.3 m (4.3 ft) deep. One troglobite (*Brackenridgia* sp.) was encountered during excavation, so presence/absence surveys were performed.

Biological surveys on this feature were conducted on 18 and 25 June, and 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-071 is included in Table 19, and microclimate measurements are included as Table 20.

Table 19. Taxa encountered in feature 281-071.

Taxa	Order	Family	Species
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
Spiders	Araneae	undetermined	(two species)
Antlion	Neuroptera	Myrmeleontidae	undetermined (nymph)
Gnats	Diptera*	undetermined	
True Bugs	Hemiptera*	undetermined	
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. *
Field Crickets	Orthoptera	Gryllidae*	(adult and nymph)
Springtails	Collembola*	undetermined	
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Barklice	Psocoptera*	undetermined	
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Gekkos	Squamata	Gekkonidae	*Hemidactylus turcicus**
Mice	Rodentia*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 20. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-071.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
18 June	-	-	-	-	-	-
25 June	1153	Surface	24.7	31.8	974	56.1
25 June	1204	In cave	25.2	28.0	974	79.9
1 Sept	-	-	-	-	-	-
9 Sept	1017	Surface	25.3	27.5	977	83.8
9 Sept	1021	In cave	21.7	25.5	977	71.8
16 Sept	1350	Surface	26.5	30.5	970	73.2
16 Sept	1442	In cave	24.5	29.2	970	68.2

Figure 118. Overview of feature 281-071.

Figure 119. Interior of feature 281-071 prior to excavation.

Figure 120. Interior of feature 281-071 after excavation.

281-072, solution cavity/enlarged bedding plane This is an enlarged bedding plane opening that is 2.5 m (8.2 ft) wide, 0.4 m (1.3 ft) tall, and extends 1.5 m (4.9 ft) into the road cut (Figure 121). Tiny mesocavernous voids extend off of it in the same bedding plane as surrounding caves and features (Figure 122). This feature was not recommended for excavation (Table 1).

Figure 121. Overview of feature 281-072.

Figure 122. Interior of feature 281-072.

281-073, Cool Cave This feature is developed in an enlarged bedding plane in the east road cut of US 281. When initially assessed, its entrance was 2 m (6.6 ft) wide and 0.5 m (1.6 ft) high (Figure 123). It extended at least 3 m (9.8 ft) into the road cut, with mesocavernous voids continuing on. It was excavated on 15-16 June 2010. Three m^3 (106 ft^3) of material was removed utilizing 20 person-hours of labor with hand and power tools (Figure 124). This resulted in enlargement of the entrance to 1 m (3.3 ft) in height, and enabled access to the full 10 m (32.8 ft) length of the cave (Figure 125). It was named for the cool temperature inside relative to the outside summer heat. The cave begins as a dirt-floored crawl, and widens out to 3.5 m (11.5 ft) across. At this point there is a shallow pit on the north side of the passage with a damp bedrock floor. The back portion of the cave gets very low. The post-excavation dimensions of this feature were 10 m (32.8 ft) long by 1 m (3.3 ft) wide by 1.2 m (3.9 ft) deep.

Biological surveys on this feature were conducted on 18 and 25 June, and 1, 9, and 16 September 2010 (Figure 126). A complete list of fauna encountered in 281-073 is included as Table 21, and microclimate measurements are included as Table 22.

Table 21. Taxa encountered in feature 281-073.

Taxa	Order	Family	Species
Spiders	Araneae	Dictynidae	*Cicurina varians* (female)
		Dictynidae	*Cicurina* sp. (eyed, immature)
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. *(**T**)
Springtails	Collembola	Entomobryidae	undetermined
			*Pseudosinella violenta** (**T**)
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi*
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (immature)

Taxa	Order	Family	Species
			Ceuthophilus sp. B
			*Ceuthophilus cunicularis**
Field Crickets	Orthoptera	Gryllidae*	undetermined
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
		Bufonidae	*Bufo nebulifer**
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Flies and Gnats	Diptera*	undetermined	
Cockroaches	Blattaria*	undetermined	

*sight identification

Table 22. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-073.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
18 June	-	-	-	-	-	-
25 June	1111	Surface	24.7	29.5	974	67.7
25 June	1115	In cave	23.7	24.8	974	91.3
25 June	1125	In cave	21.4	21.7	974	97.4
1 Sept	-	-	-	-	-	-
9 Sept	1040	Surface	25.5	27.3	977	86.6
9 Sept	1059	In cave	24.5	24.7	971	98.4
16 Sept	1415	Surface	26.5	30.5	970	73.2
16 Sept	1455	In cave	26	26.5	970	96.1

Figure 123. Entrance to Cool Cave prior to excavation.

Figure 124. Entrance to Cool Cave after excavation.


Figure 125. Interior of Cool Cave after excavation.

Figure 126. Glue trap retrieved from Cool Cave containing *Texoreddellia* subterranean silverfish and *Ceuthophilus cunicularis* cave crickets.

281-074, solution cavity/enlarged bedding plane This enlarged bedding plane opening is in the road cut on the east side of US 281 (Figure 127). It is 1 m (3.3 ft) wide, 0.3 m (1 ft) tall, and extends into the road cut for 1 m (3.3 ft) (Figure 128). This feature was not recommended for excavation (Table 1).

Figure 127. Overview of feature 281-074.

Figure 128. Interior of feature 281-074.

281-075, solution cavity/enlarged bedding plane This feature is an enlarged bedding plane developed in the east road cut of US 281. When initially assessed it was 1 m (3.3 ft) wide, 0.4 m (1.3 ft) tall, and extended into the road cut for 1.5 m (4.9 ft) (Figure 129). It contained black, modern soil, rocks, and leaf litter. This feature receives channelized flow from the highway bar ditch. The troglophile meshweaver spider *Cicurina varians* was found in this feature. Excavation was conducted on 15 June 2010. Eight person hours of effort utilizing hand tools resulted in the removal of 1 m^3 (35 ft^3) of material. This resulted in the enlargement of the entrance to 1.5 m (4.9 ft) in diameter, and the floor was lowered to 1 m (3.3 ft) below the elevation of the bar ditch for a total depth of 2 m (6.6 ft). The floor was composed of clay that extended up the walls to meet the bedrock ceiling, with no voids visible (Figure 130).

Figure 129. Overview of feature 281-075.

Figure 130. Interior of feature 281-075 after excavation.

281-076, solution cavity/enlarged bedding plane This is an enlarged bedding plane in the east road cut of US 281. The entrance to the feature is 0.5 m (1.6 ft) wide and 0.3 m (1 ft) tall (Figure 131). It extends into the road cut for 1 m (3.3 ft). It contains no infill material (Figure 132). This feature was not recommended for excavation (Table 1).

Figure 131. Overview of feature 281-076.

Figure 132. Interior of feature 281-076.

281-077, solution cavity/enlarged fracture This feature is an enlarged fracture trending at 150 degrees. It is situated in the east road cut of US 281 (Figure 133). The entrance is 0.25 m (0.8 ft) wide, 0.25 m (0.8 ft) tall, and it extends into the road cut for 0.4 m (1.3 ft). It has minor amounts of rock infill, and flowstone covering some surfaces (Figure 134). Gastropod shells were observed in this feature. This feature was not recommended for excavation (Table 1).

Figure 133. Overview of feature 281-077.

Figure 134. Interior of feature 281-077.

281-078, solution cavity/animal burrow This feature is located in the east road cut of US 281. It is an enlarged bedding plane with an entrance that is 0.4 m (1.3 ft) wide and 0.2 m (0.7 ft) high. It extends at least 1.5 m (4.9 ft) into the road cut with a continuing void, and has slight airflow (Figure 135). It was excavated on 21 June 2010. Utilizing 6 person-hours of labor, 1 m^3 (35 ft^3) of material was removed; no continuing voids were seen (Figure 136). Post-excavation dimensions of the feature were 1.5 m (4.9 ft) long by 1 m (3.3 ft) wide by 0.5 m (1.6 ft) deep. The only fauna observed in this feature were two centipedes, one in the order Geophilomorpha and the other in the order Lithobiomorpha (family Lithobiidae). This feature appears to be an animal burrow.

Figure 135. Overview of feature 281-078.

Figure 136. Interior of feature 281-078 after excavation.

281-079, animal burrow This feature is located on private property on the east side of US 281. The entrance is 0.4 m (1.3 ft) wide, 0.3 m (1 ft) tall, and it extends in for at least 0.5 m (1.6 ft) (Figure 137). It appears to be epikarstic void that was enlarged by animal burrowing (Figure 138). This feature was not recommended for excavation (Table 1).

Figure 137. Overview of feature 281-079.


Figure 138. Interior of feature 281-079.

281-080, Power Pole Hole, cave This cave is located on the west side of US 281, to the south of Sonterra Boulevard. It is just inside the ROW, about 8 m (26.2 m) from the edge of pavement of the US 281 feeder road (Figure 139). This is a cave that was apparently intersected by power pole drilling installation operations sometime in the past. Although this feature was partially open when initially assessed, excavation was needed to remove fill material that had been dumped in, in order to access karst invertebrate habitat for sampling. A large quantity of recycled asphalt had been dumped into the cave in an apparent effort to plug the cave. Excavations were conducted on 20 May, 11, 12, 17, and 29 June, 19, 20, and 26 August, and 10 and 17 September 2010. A total of 8.16 m^3 (288 ft^3) of material was removed from the feature using 97.8 person-hours of effort.

The entrance to Power Pole Hole is 0.8 m (2.6 ft) in diameter and was covered with a limestone slab when initially encountered. The entrance appears to be a drilled hole created to anchor a power pole (Figure 140). The pole was installed in a new foundation 1 m (3.3 ft) to the southwest, presumably after the drillers realized that they had hit a void. Judging by fill-plugged in-feeders just below the surface, this cave may have had a natural entrance (or associated karst feature) in the ROW just to the east that was graded over during highway construction. When initially assessed, the cave consisted of a 3 m (9.8 ft) climb-down to a plugged floor. Fill material sloped down to the south end where two copper ground rods penetrated the ceiling from the power pole above (Figure 141). Excavation efforts concentrated on removing asphalt fill and opening up apparent passages extending off to the north and south. The northern crawlway went for 3 m (9.8 ft) to a terminus. The southern crawlway went down the slope past the ground rods, and then sloped upward in a low section that opened up into a spacious chamber (Figure 142). This chamber is about 7 m (23 ft) across and up to 4.5 m (14.8 ft) in height. Flowstone and stalactites cover parts of the ceiling, walls, and floor (Figure 143). Most of the floor consists of silt. Mesocavernous voids extend off of the western portion of the room at different points of the walls and ceiling. Post-excavation dimensions of this feature were 13 m (42.7 ft) long by 5 m (16.4 ft) wide) by 1 m (3.3 ft) deep.

This cave receives a considerable amount of moisture from various sources. Drainage is channeled into it by landscaping modifications related to an adjacent hotel. The hotel filtration pond drains into it. Sprinklers installed to water the grass on the ROW also wet the cave.

Biological surveys on this feature were conducted on 16 and 24 September and 1 October 2010 (Figure 144). A complete list of fauna encountered in 281-080 is included as Table 23, and microclimate measurements are included as Table 24. A map of Power Pole Hole is presented in Figure 145.

Table 23. Taxa encountered in feature 281-080.

Taxa	Order	Family	Species
Scorpions	Scorpiones	Vaejovidae	*Pseudouroctonus reddelli*
Spiders	Araneae	undetermined	
		Dictynidae	*Cicurina varians* (immature)
		Dictynidae	*Cicurina* sp. (eyed)
		Dictynidae	*Cicurina bullis*#
Pseudoscorpions	Pseudoscorpionida	undetermined (eyeless)	
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Springtails	Collembola	Entomobryidae	undetermined
			*Pseudosinella violenta**
Harvestmen	Opiliones	Stygnopsidae	*Chinquipellobunus* sp. (**T**)
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)
		Armadillidiidae	*Armadillidium vulgare**
Millipedes	Spirostreptida	Cambalidae	*Cambala speobia* (**T**)
	Polydesmida	Paradoxosomatidae	*Oxidus gracilis*
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymphs)
			Ceuthophilus cunicularis
Field Crickets	Orthoptera	Gryllidae*	undetermined
Centipedes	Geophilomorpha	undetermined	
		Lithobiidae	undetermined
Earwig-like Diplurans	Diplura	Campodeidae	
Beetles	Coleoptera	undermined	(larva)
		Staphylinidae	undetermined
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Flies and Gnats	Diptera*	undetermined	
Earwigs	Dermaptera*	undetermined	
Moths	Lepidoptera*	undetermined	
Termites	Isoptera*	undetermined	
Snails	Gastropoda	undetermined	
	Stylommatophora	Helicodiscidae	*Helicodiscus* sp.
Gekkos	Squamata	Gekkonidae	*Hemidactylus turcicus**
Salamander	Caudata	Plethodonitdae	*Plethodon albagula**
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**

*sight identification; (**T**) indicates troglobite; # See Appendix G for taxonomic verification

Table 24. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-080 (Power Pole Hole).

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
18 June	-	-	-	-	-	-
16 Sept	0937	Surface	27	31	979	73.4
16 Sept	1004	In cave	27	30	979	79.3
16 Sept	1139	In cave	24	24.5	981	96
24 Sept	1051	Surface	30.5	24.9	981	63.5
24 Sept	1130	In cave	25.5	26.5	986	92.3
24 Sept	1125	In cave	24	26	986	84.8
1 Oct	1130	Surface	19.9	27.8	976	48.2
1 Oct	1138	In cave	25.6	26.6	976	92.3
1 Oct	1157	In cave	24.2	24.4	976	98.4

Figure 139. The entrance to Power Pole Hole had a rock partially covering it when initially assessed.

Figure 140. The circular drilling pattern can be seen in this image of the Power Pole Hole entrance.

Figure 141. A copper power pole ground rod pierces the ceiling at the entrance to the South Crawl in Power Pole Hole. A tar-like substance covers portions of the walls, apparently associated with the pole installation.

Figure 142. The South Crawl goes up a slope to emerge into the South Chamber in Power Pole Hole.


Figure 143. The South Chamber walls are partially covered in flowstone.

Figure 144. A biologist inspects the silt-covered floor of the South Chamber.

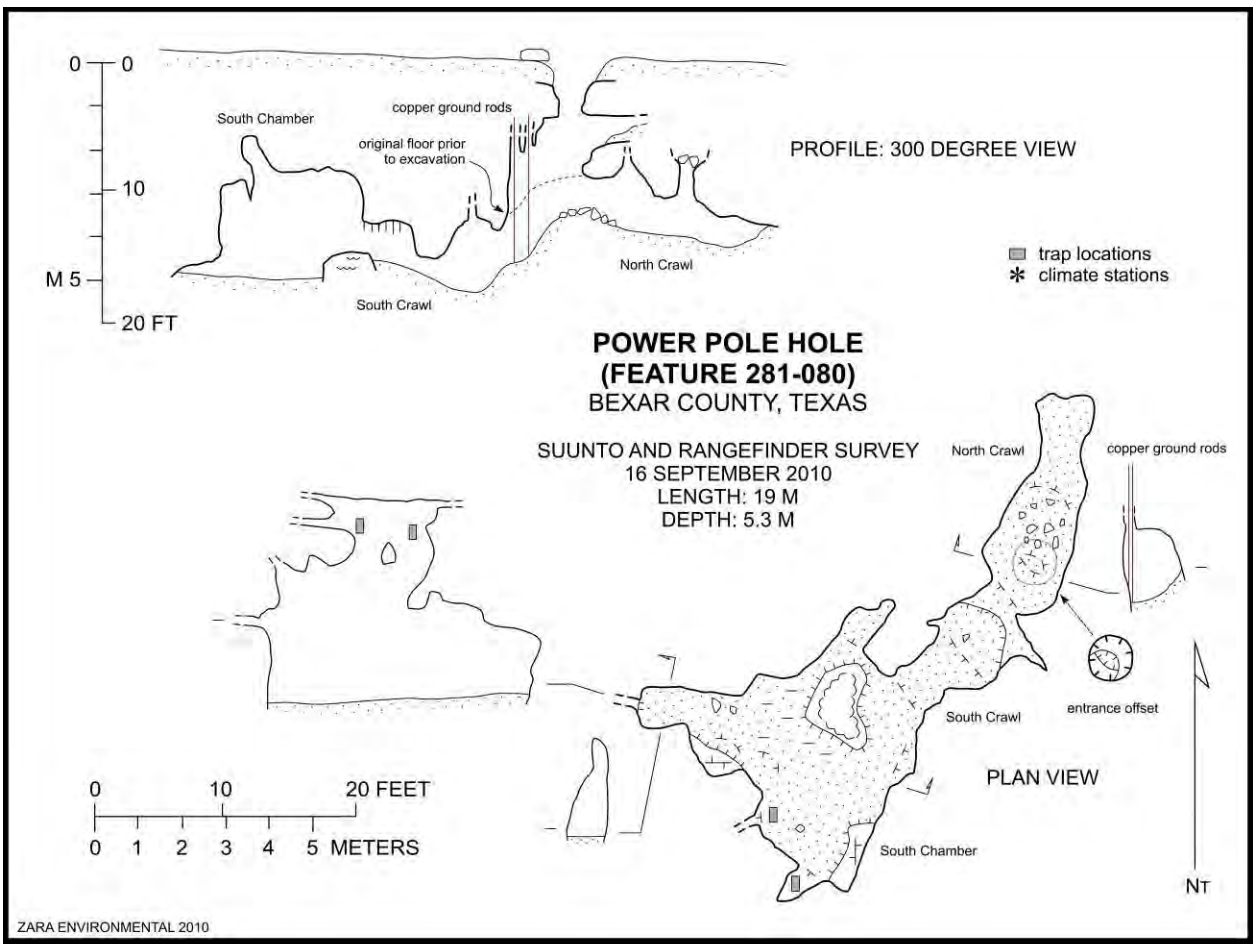

Figure 145. Map of Power Pole Hole.

281-081, solution cavity/enlarged bedding plane This feature is located in the west road cut of US 281. It is an enlarged bedding plane with an entrance that is 1.5 m (4.9 ft) wide and 0.3 m (1 ft) high (Figure 146). It can be seen to extend into the road cut for at least 1.25 m (4.1 ft). This passage is initially 0.4 m (1.3 ft) wide, and splits into two branches which become smaller (Figure 147). The right hand branch contains some concrete in it of unknown origin. This concrete may have flowed out of this branch when some feature was plugged above it. Aside from the concrete, this feature has no infill material. Visible surfaces are covered with calcite. This feature was not recommended for excavation (Table 1).

Figure 146. Overview of feature 281-081.

Figure 147. Interior of feature 281-081. Concrete can be seen on the right rear side.

281-082, solution cavity/enlarged bedding plane This feature is located in the west road cut of US 281. It is an enlarged bedding plane with an entrance that is 3 m (9.8 ft) wide and 0.5 m (1.6 ft) high (Figure 148). It extends into the road cut for 1 m (3.3 ft), and has no voids extending off of it. It contains no infill material and exhibits no evidence of moisture or speleothems (Figure 149). This feature was not recommended for excavation (Table 1).

Figure 148. Overview of feature 281-082.

Figure 149. Interior of feature 281-082.

281-083, Dripstone Cave This cave is located in the western road cut of US 281, to the south Marshall Road. It is formed in an enlarged bedding plane. Two entrances 3 m (9.8 ft) apart join up as a wide, low bedding plane void that was likely formed under phreatic[5] conditions (Figure 150). The cave is 13 m (42.7 ft) long by 5 m (16.4 ft) wide by 1 m (3.3 ft) deep. This cave is located at the very base of the road cut, and receives channelized recharge from the bar ditch. The entrance had been previously excavated. The walls and ceiling of this cave are mostly covered in calcite, which gave rise to the name Dripstone Cave (Figure 151). The floor is covered in loose, calcite-encrusted rocks. There is little organic debris, apart from some mammal scat. Several small voids extend off of the back of the cave (Figure 152).Biological surveys on this feature were conducted on 14, 21, and 29 June and 9 and 16 September 2010. A complete list of fauna encountered in 281-083 is included as Table 25.

Table 25. Taxa encountered in feature 281-083.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed)
		undetermined	(eyeless)
		Dictynidae	*Cicurina varians*
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp.* (**T**)
Springtails	Collembola	Entomobryidae	undetermined
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi*
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymphs)
			*Ceuthophilus cunicularis**
Beetles	Coleoptera	Carabidae	undetermined
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**

[5] Phreatic: below the water table; indicating the feature was completely full of water and dissolution occurs in all directions.

Taxa	Order	Family	Species
Flatworm	Tricladida-Terricola	undetermined	
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
	Anura*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 26. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-083. On 14 June 2010, pressure was obtained from weatherunderground.com-Encino Park, The Ridge.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
14 June	1323	Surface	25.4	33.8	1010	50.6
14 June	1323	In cave	25.7	27.8	973	84.6
21 June	1005	Surface	24.5	29.3	973	67.6
21 June	-	In cave	24.5	25.6	973	91.4
29 June	0911	Surface	24.9	27.4	970	81.7
29 June	0920	In cave	24.9	25.5	970	95.3
9 Sept	1304	Surface	26.5	30.9	970	71
9 Sept	1327	In cave	26.8	27.0	970	98.5
16 Sept	1505	Surface	23.5	32	970	49.1
16 Sept	1510	In cave	27	28.5	969	89.1

Figure 150. Exterior of feature 281-083.


Figure 151. Interior of feature 281-083, with baited glue trap on left.

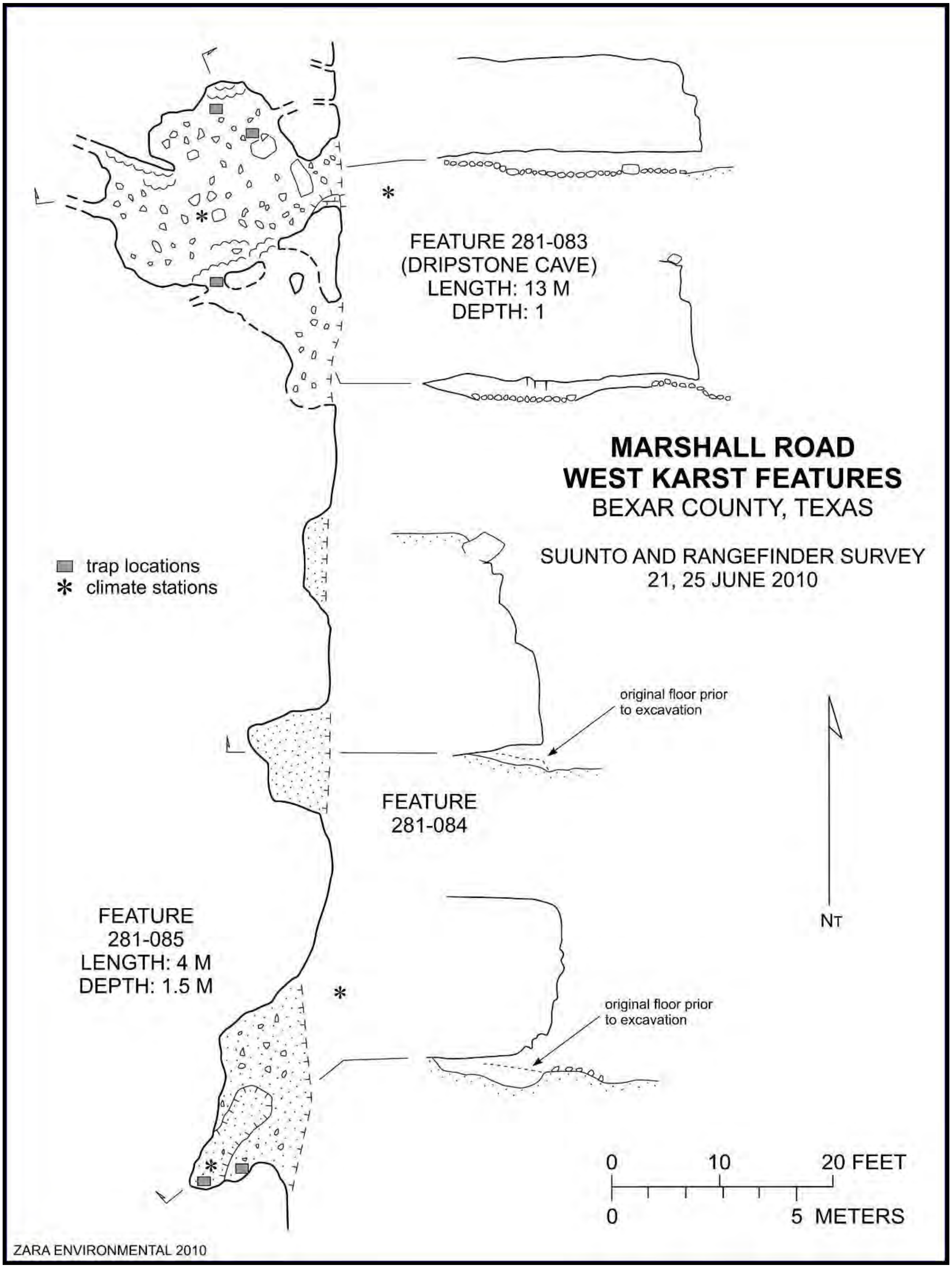

Figure 152. Map of features 281-083 through 281-085.

281-084, solution cavity/enlarged bedding plane This feature is located on the west side road cut of US 281, to the south of Marshall Road. It is formed in an enlarged bedding plane. When initially assessed the entrance was 1.3 m (4.3 ft) wide and 0.35 m (1.1 ft) high, and it extended over 1.5 m (4.9 ft) into the road cut (Figure 153). The passage made an 80 degree turn to the right beyond which it could not be examined, and thus was considered to be potentially humanly enterable. It was excavated on 18 June 2010. Using hand tools, 1.25 m^3 (44 ft^3) of material was removed with 9.5 person hours of effort. This enlarged the feature to 3 m (9.8 ft) in width 1.25 m (4.1 ft) in height, and it extended just over 2 m (6.6 ft) into the road cut. No continuing voids existed (Figure 154). Fauna encountered in feature 281-084 are included in Table 27.

Table 27. Taxa encountered in feature 281-084.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	
		Dictynidae	*Cicurina varians*
Subterranean Silverfish	Zygentoma	Nicoletiidae	
Beetles	Coleoptera	Carabidae	undetermined
Lizards	Squamata	Phrynosomatidae	*Sceloporus poinsettii**

*sight identification

Figure 153. Overview of feature 281-084 prior to excavation.

Figure 154. Interior of feature 281-084 after excavation.

281-085, solution cavity/enlarged bedding plane This feature is located in the western road cut of US 281, to the south Marshall Road. It is formed in an enlarged bedding plane at the base of the road cut, and it takes channelized drainage from the bar ditch (Figure 155). The entrance is 4 m (13.1 ft) wide and 2 m (6.6 ft) tall. When initially assessed it quickly became too low to enter, but extended at least 3 m (9.8 ft) into the road cut and was considered to be potentially humanly-enterable. Excavation was conducted on 18 June 2010 for 6 person hours, removing 0.75 m^3 (26.5 ft^3) of material from the feature. The floor was lowered, enabling the back of the feature to be examined. Post-excavation dimensions of the feature were 4 m (13.1 ft) in width and 2.5 m (8.2 ft) in height and extended 3 m (9.8 ft) into the road cut. No voids continued on (Figure 156), but the detection of troglobitic species during excavation prompted the initiation of presence/absence surveys. Biological surveys on this feature were conducted on 25 June and 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-085 is included as Table 28.

Table 28. Taxa encountered in feature 281-085.

Taxa	Order	Family	Species
Isopods	Isopoda	Trichoniscidae	*Brackenridgia* sp. (**T**)*
Spiders	Araneae	undetermined	(eyed)
		Dictynidae	*Cicurina* sp. (eyed)
Centipedes	Scolopendromorpha	Cryptopidae	*Theatops* sp.
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymphs)
			Ceuthophilus cunicularis
			*Ceuthophilus secretus**
Flies and Gnats	Diptera*	undetermined	
Frogs	Anura*	undetermined	

*sight identification; (**T**) indicates troglobite

Table 29. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-085.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
25 June	1330	Surface	25.4	32.2	973	58.1
25 June	1345	In cave	24.5	25.3	973	93.7
1 Sept	-	-	-	-	-	-
9 Sept	1304	Surface	26.5	30.9	970	71
9 Sept	1313	In cave	26.9	27.5	970	95.5
16 Sept	1438	Surface	26.5	30.5	970	73.2
16 Sept	1455	In cave	27	28	969	92.6

Figure 155. Overview of feature 281-085.


Figure 156. Interior of feature 281-085 after excavation.

281-086, solution cavity/enlarged bedding plane This feature is located in the western road cut of US 281, to the south Marshall Road. It is formed in an enlarged bedding plane. The entrance is 2 m (6.6 ft) wide and 0.45 m (1.5 ft) high (Figure 157). It extends 1 m (3.3 ft) into the road cut, at which point a small portal that is not humanly-enterable continues for an unknown distance (Figure 158). It is formed at the base of the road cut, taking channelized drainage from the bar ditch. Previous excavation has occurred here, as evidenced by a tailings pile just outside of the entrance. This feature was not recommended for additional excavation (Table 1).

Figure 157. Exterior of feature 281-086.

Figure 158. Interior of feature 281-086.

281-087, solution cavity/enlarged bedding plane This feature is located in the western side road cut of US 281, to the south Marshall Road. It is formed in an enlarged bedding plane. The entrance is 3 m (9.8 ft) wide and 1.5 m (4.9 ft) high (Figure 159). It extends 1.5 m (4.9 ft) into the road cut. There is no soil infill, and some of the surfaces are covered in calcite. There are no mesocavernous voids extending from the feature (Figure 160). This feature was not recommended for excavation (Table 1).

Figure 159. Overview of feature 281-087.

Figure 160. Interior of feature 281-087.

281-088, Zombie Cave This feature was revealed by roadway widening construction in June 2010 (Figure 161). The entrance was 3 m (9.8 ft) wide, 0.5 m (1.6 ft) tall, and it could be seen to extend into the road cut for at least 4 m (13.1 ft). It was excavated on 23 and 26 August. Excavation removed rocks from the floor to enable access to the interior of the cave (Figure 162). Features 281-089 and 281-091, which are adjacent to the south, were found to connect to it, giving this cave three entrances (Figure 163). All three entrances open into the same enlarged bedding plane, which it shares with other nearby caves in the road cuts south of Marshall Road. Noticeable airflow circulates through this cave, probably between these three entrances rather than from other sources. Maximum human penetration in Zombie Cave from the road cut to date is about 6 m (19.7 ft), but the enlarged bedding plane opening can be seen to continue on in a number of places which could be enlarged with more excavation effort. However, the excavation effort invested in this cave resulted in access to dark zone habitat and was deemed sufficient for the purposes of this study. At 38 m (124.7 ft), this cave is the longest one encountered in the course of this study. Post-excavation dimensions of the cave are 38 m (124.7 ft in length with an average width of 5 m (16.4 ft) and a depth of 1.5 m (4.9 ft). The cave was named for the fact that it suddenly appeared from out of the earth.

Biological surveys on this feature were conducted on 25 June and 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-085 is included in Table 30.

Table 30. Taxa encountered in feature 281-088.

Taxa	Order	Family	Species
Spiders	Araneae	undetermined	(eyed)*
Cave Crickets	Orthoptera	Rhaphidophoridae	*Ceuthophilus* sp. (nymphs)
			*Ceuthophilus cunicularis**
			*Ceuthophilus secretus**
Flies and Gnats	Diptera*	undetermined	
Frogs	Anura	Leptodactylidae	*Eleutherodactylus marnockii**
Mice	Rodentia*	undetermined	

*sight identification

Table 31. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-088 (Zombie Cave).

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
25 July	1020	Surface	23.8	28.0	974	70.6
25 July	1026	In cave	23.7	24.5	974	93.6
25 July	1032	In cave	24.2	24.7	974	96.8
1 Sept	-	-	-	-	-	-
9 Sept	1531	Surface	26.6	31.4	974	68.8
9 Sept	1340	In cave	26.5	27.8	974	90.3
9 Sept	1353	In cave	26.7	27.9	974	91.1
16 Sept	1525	Surface	-	-	-	-
16 Sept	1539	In cave	25	26.5	969	88.6


Figure 161. Entrance to feature 281-088 prior to excavation.


Figure 162. Interior of feature 281-088.

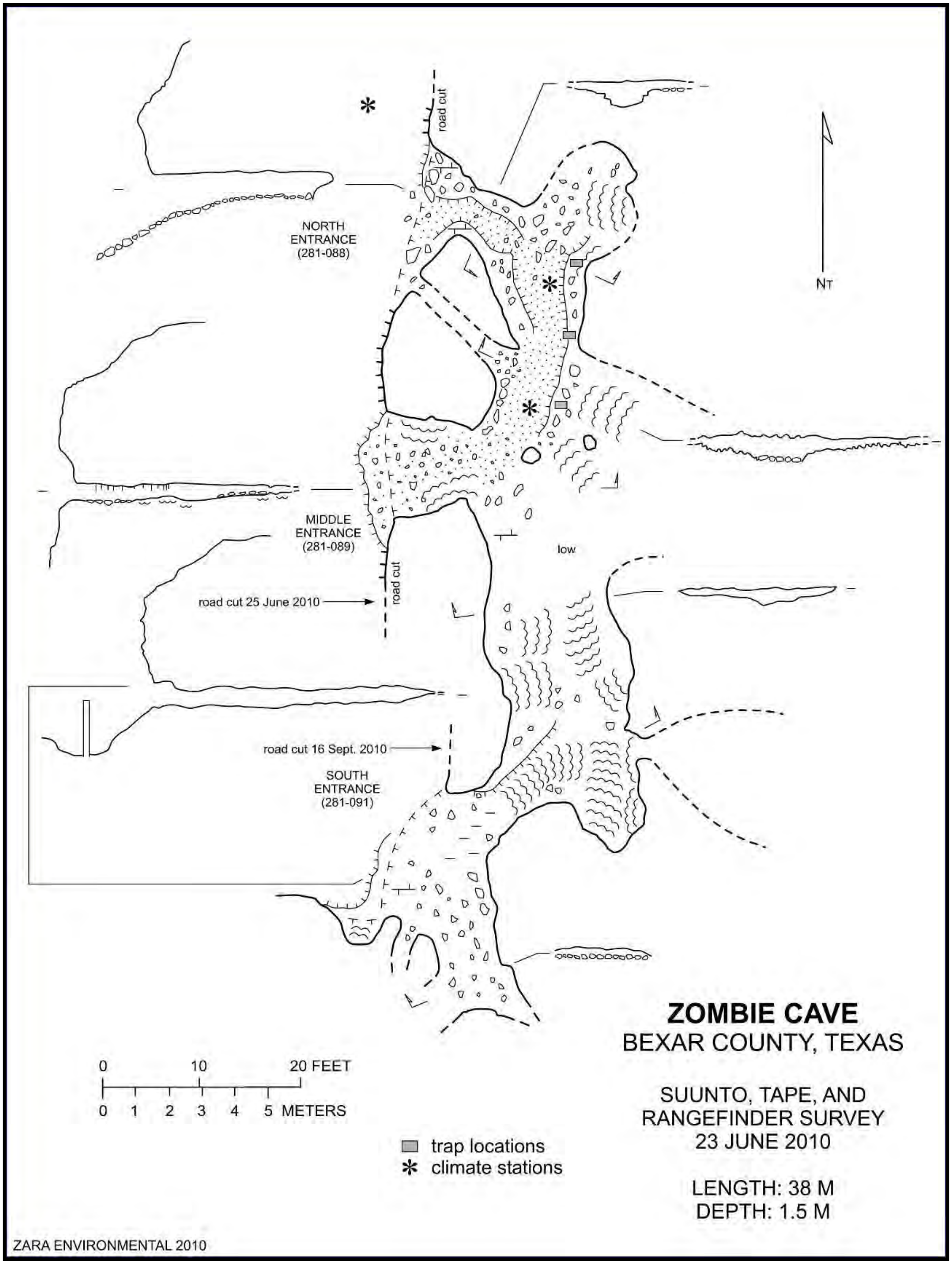

Figure 163. Map of Zombie Cave (features 281-088, 281-089, and 281-091).

281-089, Zombie Cave This karst feature is located in the road cut just south of Zombie Cave, and upon excavation and investigation was found to connect to it (Figure 164). See the description of 281-088 for more information.

Figure 164. Entrance to feature 281-089 prior to excavation.

281-090, solution cavity In August 2010 a construction team working on the installation of a traffic signal at the intersection of Evans Road and 281 encountered a karst feature while drilling a 1 m (3.3 ft) diameter foundation (Figure 165). Excavations were conducted on 25 and 26 August 2010 to remove drilling rubble in order to assess the void for karst invertebrate habitat (Figure 166). The drilled shaft was 3 m (9.8 ft) deep, with the void extending off of the north wall. The opening into the void extended from the floor of the shaft at -3 m (-9.8 ft) to a point 1.6 m (5.2 ft) above that. The total vertical extent of the void was 3 m (9.8 ft), with tiny voids extending off of the top and bottom of it. Post-excavation dimensions of the feature were 2 m (6.6 ft) long by 2.5 m (8.2 ft) wide and 3 m (9.8 ft) deep. Most of the surfaces within the void were encrusted with calcite, including the floor drain which effectively plugged it (Figure 167). Although the feature did not necessarily meet all of the guidelines presented in USFWS (2006) for warranting excavation or subsequent presence/absence surveys, a troglobitic species (*Texoreddellia sp.*) was encountered during excavation, prompting the initiation of presence/absence surveys, which were carried out on 1, 9, and 16 September 2010. A complete list of fauna encountered in 281-090 is included in Table 32. A map is presented in Figure 168.

Table 32. Taxa encountered in feature 281-090.

Taxa	Order	Family	Species
Subterranean Silverfish	Zygentoma	Nicoletiidae	*Texoreddellia* sp. (**T**)
Springtails	Collembola	Entomobryidae	undetermined
Harvestmen	Opiliones	Sclerosomatidae	*Leiobunum townsendi**
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**
Field Crickets	Orthoptera	Gryllidae*	undetermined

*sight identification; (**T**) indicates troglobite

Table 33. Dates of biological surveys and in-cave temperature and humidity measurements at feature 281-090. The first biological survey performed on 8 April included collections and trap deployment, but in-cave temperature and humidity parameters were not measured.

2010 Date	Time	Location	Wet Bulb (°C)	Dry Bulb (°C)	Pressure (mb)	% Humidity
1 Sept	-	-	-	-	-	-
9 Sept	1138	Surface	26.5	30.5	971	73.2
9 Sept	1146	In cave	27.5	29.5	971	85.8
16 Sept	1343	Surface	23	34.4	977	37.7
16 Sept	1355	In cave	27.8	29.5	977	87.9


Figure 165. Overview of feature 281-090.


Figure 166. View down drilled shaft at feature 281-090 after excavation.


Figure 167. View of calcite-plugged drain in feature 281-090.

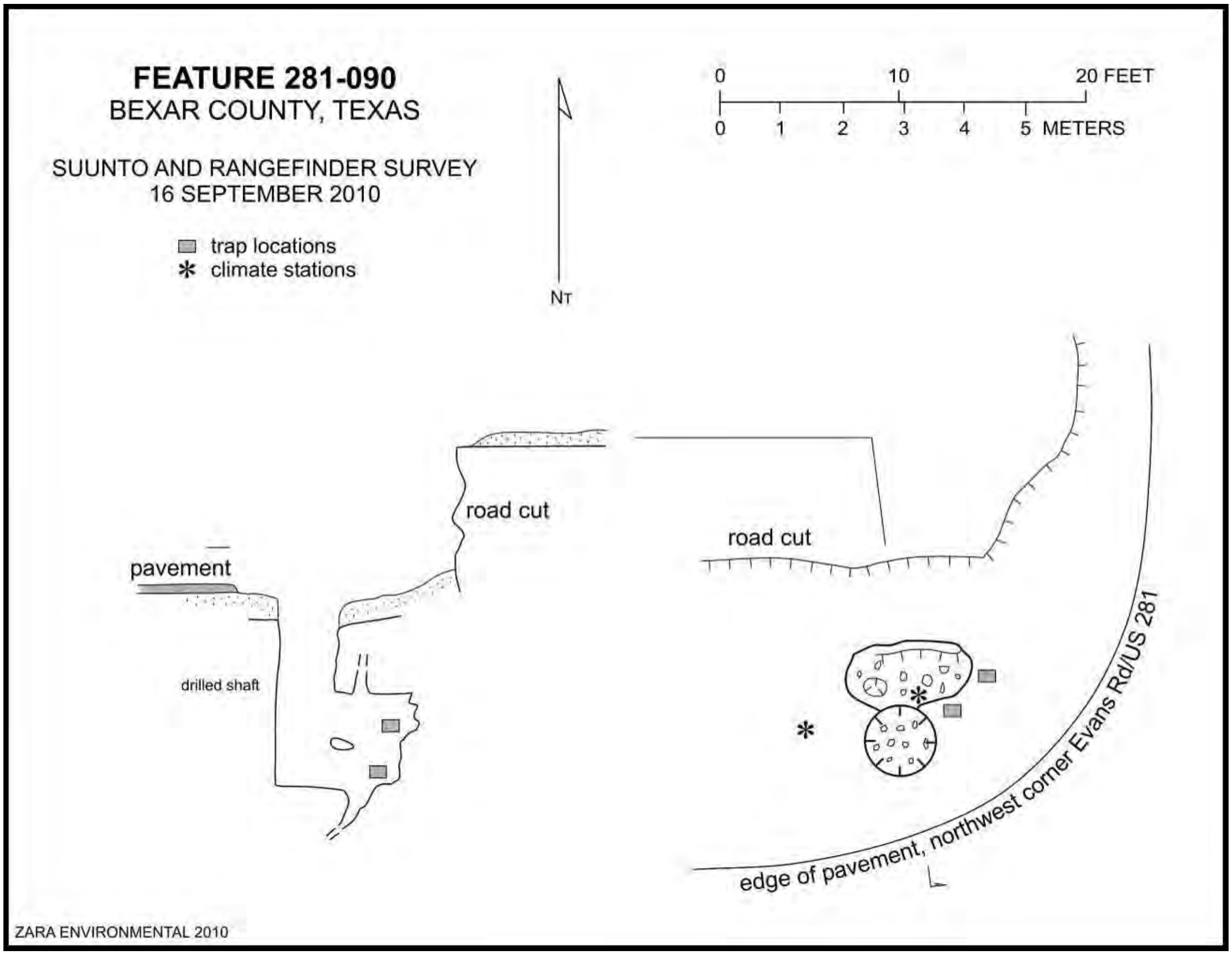

Figure 168. Map feature 281-090.

281-091, Zombie Cave This is another feature located in the road cut south of Zombie Cave (Figure 169). This feature was exposed during road widening activities in August 2010. Excavation conducted at that time resulted in its connection to Zombie Cave. See the description of 281-088 for more information.

Figure 169. Overview of feature 281-091 prior to excavation.

281-092, fault This feature is a geologic fault exposed in the road cut on the west side of US 281. It was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-093, fault This feature is a geologic fault exposed in the road cut on the west side of US 281. It was recorded for purposes of the Geological Assessment. It is not a karst feature.

281-094, non-karst closed depression This is a shallow depression that is 4 m (13.1 ft) long, 1.5 m (4.9 ft) wide, and 0.3 m (1 ft) deep. It has a hard-packed clay floor, with no drains (Figure 170). It is likely the result of land clearing operations. This feature was not recommended for excavation (Table 1).

Figure 170. Overview of feature 281-094.

281-095, solution cavity This solution cavity is located in the eastern road cut of US 281. When initially assessed, it was 1 m (3.3 ft) wide, 1.3 m (4.3 ft) tall, and it extended into the road cut for 0.5 m (1.6 ft) (Figure 171). It contained some gravel infill that may be associated with construction excavation activities. The walls were partially covered with calcite. It is developed along a fracture trending at approximately 133 degrees. It was excavated on 1 October 2010. This effort removed 1 m^3 (35 ft^3) of material utilizing 6 person hours of labor. The feature was enlarged along the fracture to yield post-excavation dimensions of 1 m (3.3 ft) wide by 2 m (6.6 ft) tall, and it extended 1 m (3.3 ft) into the road cut (Figure 172). The fracture narrowed nearly to closure, with no airflow. A list of fauna encountered in feature 281-095 is included as Table 34.

Table 34. Taxa encountered in feature 281-095.

Taxa	Order	Family	Species
Spiders	Araneae	Dictynidae	*Cicurina* sp. (immature)
Ants	Hymenoptera	Formicidae	*Solenopsis invicta**

*sight identification

Figure 171. Overview of feature 281-095.


Figure 172. Interior of feature 281-095 after excavation.

281-096, solution cavity/enlarged fracture This enlarged fracture is situated in the eastern road cut of US 281. It is 1 m (3.3 ft) wide, 1.2 m (3.9 ft) tall, and it extends into the road cut for 1.5 m (4.9 ft) (Figure 173). It contains some gravel infill that may be associated with construction excavation activities (Figure 174). This feature was not recommended for excavation (Table 1).


Figure 173. Overview of feature 281-096.

Figure 174. Interior of feature 281-096.

281-097, non-karst closed depression This feature is a depression measuring 10 by 25 m (32.8 by 82 ft), and is 4 m (13.1 ft) deep. It is old quarry pit that has bedrock walls on three sides. The east side is composed of fill that made this a closed depression. It was most likely originally open on the east side for material removal. It was recorded for purposes of the Geological Assessment, and is not a karst feature.

281-098, solution cavity/enlarged bedding plane This feature is an enlarged bedding plane on a creek bank (Figure 175). The entrance is 0.75 m (2.5 ft) wide, 0.3 m (1 ft) tall, and it extends into the creek bank for 1.6 m (5.2 ft). A fracture is present in the feature that trends at approximately 150 degrees. It has a coarse infill of rocks (Figure 176). The roof of the feature is only about 0.5 m (4.9 ft) thick, and is in the process of being eroded away due to proximity to the creek, and this feature is a result of that process. This feature was not recommended for excavation (Table 1).


Figure 175. Overview of feature 281-098.


Figure 176. Interior of feature 281-098.

281-099, closed depression This is a probable non-karst closed depression that lies just across a fence from the ROW where ROE was denied. It is 1 m (3.3 ft) long, 0.8 m (2.6 ft) wide, and 0.2 m (0.7 ft) deep (Figure 177). It appeared to have infill of leaf litter and black, modern sediment. It may be surface disturbance associated with fence building. It was recommended for excavation, but ROE for that purpose was not obtained.


Figure 177. Overview of feature 281-099.

281-100, 281-101, water wells These features are wells that were recorded for purposes of the Geologic Assessment. They are not karst features.

281-102, solution cavity/enlarged bedding plane This feature is located in the west road cut of US 281. The entrance to it is 0.3 m (1 ft) in diameter, and it extends into the road cut for 0.3 m (1 ft) (Figure 178). It has a coarse infill of loose rocks (Figure 179). This feature was not recommended for excavation (Table 1).


Figure 178. Overview of feature 281-102.


Figure 179. Interior of feature 281-102.

281-103, solution cavity This feature is located on private property on the west side of US 281 (Figure 180). The entrance is 0.25 m (0.8 ft) wide, 0.2 m (0.7 ft) long, and when initially assessed it dropped 0.4 m (1.3 ft) to a floor composed of organic debris and soil that was loose to a depth of loose. Preliminary excavation lowered the floor 0.1 m (0.15 ft), but more excavation would have required removal of some of the bedrock walls (Figure 181). This was recommended, but ROE for that purpose was denied.


Figure 180. Overview of feature 281-103.


Figure 181. Interior of feature 281-103.

281-104, solution cavity This consists of two solution cavities in the east US 281 road cut, one of which is associated with a fracture (Figure 182). The north cavity is 0.8 m (2.6 ft) wide, 1.2 m (3.9 ft) tall, and extends into the road cut for 0.2 m (0.7 ft). The south cavity is 0.4 m (1.3 ft) wide, 1.3 m (4.3 ft) tall, and extends into the road cut for 0.7 m (2.3 ft). These contain coarse infill of rocks that is likely a consequence of road cut excavation (Figure 183). This feature was not recommended for excavation (Table 1).


Figure 182. Overview of feature 281-104.

Figure 183. Interior of feature 281-104.

281-105, solution cavity/enlarged bedding plane This feature is located in the west road cut of US 281. The entrance that is 3 m (9.8 ft) wide, 0.7 m (2.3 ft) tall, and it extends 1 m (3.3 ft) into the road cut (Figure 184). It contains no infill material (Figure 185). This feature was not recommended for excavation (Table 1).

Figure 184. Overview of feature 281-105.

Figure 185. Interior of feature 281-105.

281-106, enlarged fracture zone This is a zone of fractures in the streambed of West Elm Creek that was recorded for purposes of the Geologic Assessment. This feature was not recommended for excavation (Table 1).

281-107, solution cavity This appears to be a solution cavity encountered during down-cutting of bedrock grade in a private property construction area (Figure 186). It is 1.5 m (4.9 ft) long, 1.3 m (4.3 ft) wide, and is 0.25 m (0.8 ft) deep. It has an infill of rocks and fine white silt (powdered bedrock) that appears to have been graded into it (Figure 187). It was recommended for excavation, but ROE for excavation purposes was not obtained.

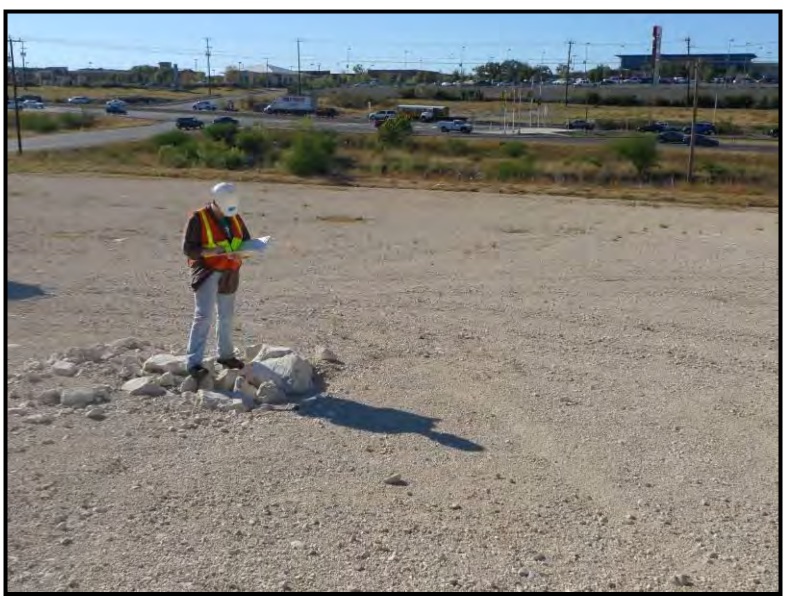

Figure 186. Overview of feature 281-107.

Figure 187. Feature 281-107 appears to have been back-filled with rocks.

281-108, non-karst closed depression This feature is located on the east US 281 ROW in an area that was partially cleared of trees in the past. It is 0.8 m (2.6 ft) long, 0.6 m (2 ft) wide, and is 0.3 m (1 ft) deep (Figure 188). When initially assessed, it had an infill of fine, modern soil. It was excavated on 16 November 2010, which resulted in the removal of 5 cm (0.2 ft) of soil to reveal a bedrock floor. This feature is probably a result of tree removal.

Figure 188. Overview of feature 281-108.

281-109, solution cavity This feature is located on private property on the west side of US 281. It consists of two 10 by 20 cm (0.3 by 0.6 ft) holes that are 1 m (3.3 ft) apart, one of them open and one plugged (Figure 189). The eastern hole drops for 0.2 m (0.7 ft) to dirt fill. This feature was recommended for excavation. No determination could be made about this feature due to lack of ROE for excavation purposes. From appearances this may be an animal burrow under a slab of rock that has been mostly filled with soil by site grading (Figure 190).


Figure 189. Overview of feature 281-109.


Figure 190. Interior of feature 281-109.

281-110, 281-111, 281-112, 281-113, 281-114, 281-115, 281-116, faults These features are mapped faults recorded for purposes of the Geological Assessment. They are not karst features.

Significant Previously Recorded Features

The following caves are listed in TSS records, but were on property where ROE was not obtained and/or have now been destroyed.

Feature 23 Cave This is a cave that was opened up by excavation, and reaches a depth of 5.6 m (15 ft), with a footprint 12 m (40 ft) across. Seventeen invertebrate species have been recorded within this cave, at least four of which are troglobites. Three presence/absence surveys conducted in 2006 did not detect any endangered karst invertebrate species.

Voight Cave No. 1 This site has a location puts it under a shopping center roadway surrounded by retail establishments, so it is doubtful that an entrance to it still exists. No presence/absence surveys for karst invertebrate species are known to have been conducted at this site.

Tiny Town Sink This cave consisted of a 10 m (33 ft) drop from a small entrance into a room 4 m (13 ft) in diameter. The cave entrance was covered during widening of US 281 in the early 1970's (Veni 1988). It is known to contain cave crickets (TSS 2010), a trogloxene species whose presence suggests the possibility for endangered karst invertebrate habitat. No presence/absence surveys for karst invertebrate species are known to have been conducted at this site; however, a list of taxa known from this cave is included in Appendix A.

C Section Cave This cave is 9 m (30 ft) deep and ends in a mud fill. This cave is known to contain cave crickets (TSS 2010), a trogloxene species whose presence suggests the possibility for endangered karst invertebrate habitat. ROE was not obtained for the location listed in TSS records; that location appears in imagery to now be under a gravel parking lot. No presence/absence surveys for karst invertebrate species are known to have been conducted at this site; however, a list of taxa known from this cave is included in Appendix A.

Significant Features Outside of Buffer

A desktop review of known caves and karst features outside of the 152 m (300 ft) buffer out to 304 m (1000 ft) from the ROW turned up 85 such features. Of these, the following three sites are notable.

Feature F-3 This feature is an enlarged fracture located 987 ft from the US 281 ROW. An open void with slight airflow was reported at this feature (SWCA 2004), suggesting the presence of a cave with potential for containing karst invertebrate habitat. No excavations or presence/absence surveys for karst invertebrate species are known to have been conducted at this site.

Pomeranian Pit This cave is located 302 m (993) ft from the US 281 ROW. It is a narrow pit that drops 9.3 m to a dirt and rubble plugged floor (Veni 1988). This cave is known to contain cave crickets (TSS 2010), a trogloxene species whose presence suggests the possibility for endangered karst invertebrate habitat. No presence/absence surveys for karst invertebrate species are known to have been conducted at this site. The apparent lack of dark zone habitat preferred by *Rhadine exilis* indicates that excavation at this site would be desirable in order to assess the possible presence of that species.

Pick-up Sticks Cave This cave is located 194 m (638 ft) from the US 281 ROW. It has a pit entrance that drops 15 m to a highly decorated chamber. It is located in a drainage and takes a considerable amount of recharge. Eleven species have been recorded from this cave, at least one of which is a troglobite (*Texoreddellia* sp.), however; presence/absence surveys for karst invertebrate species are known to have been conducted at this cave. A list of taxa known from this cave is included in Appendix A.

Climate Analysis

Detailed results of the climate analysis for each surveyed feature are presented in Appendix H, abbreviated results are presented here for ease of reference.

The first recommended climate criterion, that surveys be conducted within a season recommended by USFWS (2006), was met for all surveys. The second recommended climate criterion, that the area is experiencing "average" weather[6] for the time of year, was also met.

The monthly high, low, and average temperature and precipitation levels for survey months in 2010 were compared with the 30 year average, high and low temperature and precipitation data obtained from NOAA; the specific data are presented in Appendix H. The average temperatures for 2010 survey months were similar to the 30 year average temperatures for those months, and well within the range of the historical high and low records (Figure 191A). The precipitation levels for the 2010 survey months were similar to but fluctuated slightly from the 30 year average, but were significantly lower than record precipitation levels for the same months, and fell well within the range of the historical high and low records (Figure 191B).

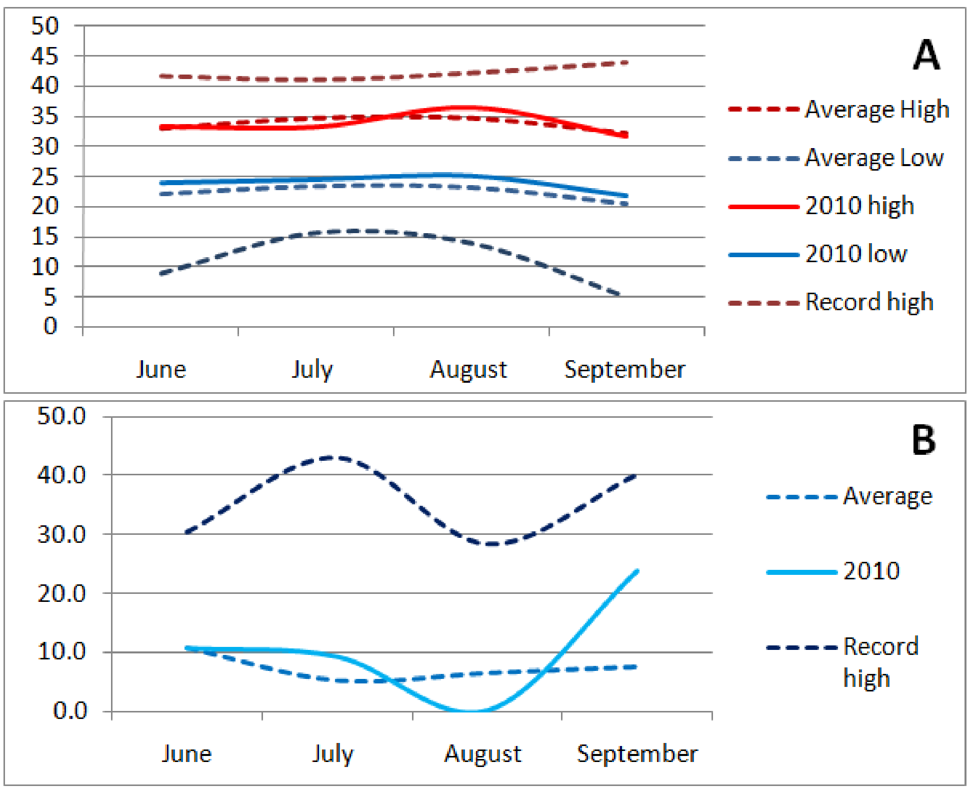

Figure 191. A) The 2010 monthly average temperatures (°C) for the survey months were near the 30 year average temperatures for the same months, and well within the historic record temperature ranges for the area. B) The 2010 monthly total precipitation (cm) for the survey months fluctuated slightly from the 30 year average precipitation for the same months, but fell well within the limits of the record levels of precipitation ranges for the area. Note that record low precipitation levels are not shown on the graph because they were 0 cm for all months indicated (NOAA 2002, 2010).

The third criterion, that surveys not be conducted within one week of exceeding the recommended surface temperature ranges, was met for each of the survey dates. The

[6] USFWS (2006) indicates that "weather" should mean temperature and precipitation.

fourth condition, lack of drought conditions, was met for all surveys. The fifth criterion, recent rainfall, was met for at least 1 survey in each feature[7]. The sixth criterion, absence of recent, extensive, local flooding, was met for each of the survey dates; however, surveys were repeated or postponed when they were scheduled to occur within two days of heavy rainfall.

[7] "Recent" is not quantified by USFWS (2006), and it is not unusual for the study area to lack rainfall for several months each year. The lack of rain within one week of some survey dates prompted the research team to perform additional surveys in some features in an effort to maximize detectability of karst invertebrates in the absence of the satisfaction of this criterion.

Conclusions and Recommendations

Surveys for listed karst invertebrate habitat were conducted within the existing ROW of US 281, and on private properties within 152 m (500 ft) of the existing and proposed ROW, where landowners granted access. Researchers recorded 116 features during these surveys, and identified 60 of them that had the potential to contain karst invertebrate habitat. Fifteen landowners that had granted access for initial karst feature surveys subsequently did not grant access to their property for excavation of recorded features. The remaining 45 features that had potential to contain karst invertebrate habitat were excavated and re-evaluated for their habitat potential. These re-evaluations led to the identifications of 13 caves and karst features that were determined to contain potential habitat and were therefore surveyed for listed karst invertebrate species.

No federally-listed karst invertebrate species were detected during presence/absence surveys for this study and none are known to historically occur within the study area. The nearest recorded localities of federally listed karst species in the area are for *Rhadine exilis,* which is known from Ragin' Cajun Cave and Hairy Tooth Cave. These caves lie within CHU 12 (USFWS 2003), the edge of which is 180 m (591 ft) from the US 281 ROW.

One specimen of troglobitic harvestman was obtained from Stafford Cave (feature 281-070). This specimen has been tentatively identified as *Texella* near *tuberculata* (Appendix G). More specimens would be needed to make a definitive determination, however; *Texella* specimens are notoriously difficult to encounter in Bexar County caves. *Texella tuburculata* is currently confirmed from only two caves in western Bexar County, Surprise Sink and Logan's Cave (Ubick 2004, 106). Surprise Sink is located within Government Canyon State Natural Area, and Logan's Cave is on privately owned land within CHU 2 (USFWS 2003); therefore, both of these localities have a measure of protection already in place. Although this species is not federally listed, it is known from fewer sites than some of the listed karst species in Bexar County. An interesting aspect of this discovery is that the addition of the Stafford Cave site extends the species range 26 km (16 mi) to the east-northeast, leapfrogging over the extremely limited ranges of three other *Texella* species, *elliotti, hilgerensis, and whitei.*

The troglobitic spider *Cicurina bullis* was identified from Power Pole Hole (feature 281-080). This is the first occurrence of this species outside of Camp Bullis, where it is known from five caves. These caves are approximately 7 km (4 mi) to the northwest of Power Pole Hole (Cokendolpher 2004, 39-40). Power Pole Hole contained eight cave adapted species, eight of which are true troglobites, giving it the most diverse subterranean fauna assemblage of all the sites studied.

Both of these rare species caves contain *Ceuthophilus* cave crickets, which are important to the condition of the subterranean ecosystem. Cave crickets forage on the surface surrounding the cave at night, but they carry out many aspects of their life cycle in the cave, such as laying eggs and the deposition of fecal matter and corpses, all of which contribute energy to the system. Although cave crickets have been shown to forage up to 105 m (344 ft) from cave entrances (Taylor et al. 2005), the surface ecosystems surrounding these particular caves are degraded because they occur within the ROW of a major thoroughfare. Potential impacts to these caves may include further alteration of the natural plant and animal community surrounding the entrances and modifications to the current surface and subsurface drainage regimes. Because these caves contain no listed species, there are no federal regulations in place governing the management of the areas surrounding them. However; because the species that occur in these caves are so rare, the potential impacts to the systems should be carefully considered when planning development activities within 105 m (344 ft) of their entrances.

As discussed in the Background Data portion of the Results Section, caves and karst features are known to exist on some of the unaccessed properties where landowners were unresponsive to or denied access. Conclusions about the status of listed karst invertebrate habitat in those areas cannot be made at this time. If access becomes available in the future, these features should be located and assessed for potential karst invertebrate habitat. Similarly, three springs identified as potential habitat foe Eurycea salamanders should be sampled if future access is obtained.

It is possible that other potential karst features or caves may be revealed if any excavation occurs below the current grade or further into existing road cuts during anticipated improvements to US 281. If this occurs, work should immediately cease within 105 m (344 ft) of the feature, the feature should be covered, and a section 10(A)(1)(a) permitted karst biologist should inspect the site as soon as possible in order to evaluate potential species habitat.

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DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX A

HISTORIC FEATURES

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
5F1	29.65596	-98.44913	not located, "unable to find - covered"	ROW	AR 1500 2007
5F4	29.65333	-98.44855	not located, "void in loose rock unable to find - covered"	ROW	AR 1500 2007
5F5	29.65159	-98.44900	not located, "CD unable to find - covered" (destroyed)	ROW	AR 1500 2007
5F6	29.65147	-98.44911	not located, "Pot SH unable to find - covered" (destroyed)	ROW	AR 1500 2007
5F7	29.65032	-98.44946	not located, "Pot SC unable to find - covered" (destroyed)	ROW	AR 1500 2007
5F8	29.64180	-98.45343	non-karst closed depression	ROW	AR 1500 2007
5F9	29.64644	-98.45220	not located, "fracture rock now road"	ROW	AR 1500 2007
5F10	29.64949	-98.45117	non-karst closed depression	ROW	AR 1500 2007
5F11	29.65026	-98.45048	not located, "unable to find - cleared" (destroyed)	ROW	AR 1500 2007
7F18	29.65422	-98.44839	not located, under pavement (destroyed)	ROW	AR 1500 2007
B5	29.63548	-98.45691	281-106	ROW	AR 1500 2007
F-1	29.62427	-98.46345	not located, fault	ROW	AR 528 2003
F-01	29.62427	-98.46345	not located, fault	ROW	AR 682 2005
F-2	29.62750	-98.46178	not located, under US 281 pavement (destroyed)	ROW	AR 528 2003
F-02	29.62920	-98.46097	281-061	ROW	AR 682 2005
F3E	29.66682	-98.44925	not located, detention pond	ROW	AR 1500 2007
F-03	29.62946	-98.46080	281-063	ROW	AR 682 2005
F4A	29.65200	-98.45018	281-045	ROW	AR 1500 2007
F4B	29.65198	-98.45027	281-045	ROW	AR 1500 2007
F-04	29.63425	-98.45767	non-karst closed depression from road cut	ROW	AR 682 2005
F5	29.65513	-98.45017	non-karst, animal burrow	ROW	AR 1500 2007
F-5	29.63538	-98.45670	281-106	ROW	AR 528 2003
F-05	29.63522	-98.45670	281-106	ROW	AR 682 2005
F-6	29.64158	-98.45350	not located, fault	ROW	AR 528 2003
F-06	29.64158	-98.45390	not located, fault	ROW	AR 682 2005
F-07	29.64182	-98.45344	non-karst closed depression	ROW	AR 682 2005
F8	29.65020	-98.44981	non-karst closed	ROW	AR 1500 2007

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
			depression		
F-08	29.64355	-98.45208	not located, other bedrock feature	ROW	AR 682 2005
F9	29.65442	-98.44859	non-karst closed depression	ROW	AR 1500 2007
F10	29.65422	-98.44858	not located, sinkhole, area has been filled (destroyed)	ROW	AR 1500 2007
F-10	29.65039	-98.45036	non-karst closed depression	ROW	AR 682 2005
F11	29.64065	-98.45398	non-karst closed depression	ROW	AR 1500 2007
F-11	29.65035	-98.44937	non-karst closed depression	ROW	AR 682 2005
F-12	29.65048	-98.44998	281-114	ROW	AR 682 2005
F-13	29.65148	-98.44914	not located, cleared/graded (destroyed)	ROW	AR 682 2005
F-14	29.65162	-98.44899	not located, cleared/graded (destroyed)	ROW	AR 682 2005
F15	29.70753	-98.45031	not located, other (likely burrow)	ROW	AR 1500 2007
F-15	29.65186	-98.45014	281-045	ROW	AR 682 2005
F-16	29.65334	-98.44857	not located, solution cavity	ROW	AR 682 2005
F17	29.68699	-98.45334	281-102	ROW	AR 1500 2007
F-17a	29.65434	-98.44859	281-108	ROW	AR 682 2005
F-17b	29.65434	-98.44859	281-108	ROW	AR 682 2005
F-17c	29.65434	-98.44859	281-108	ROW	AR 682 2005
F-17d	29.65434	-98.44859	281-108	ROW	AR 682 2005
F18	29.62919	-98.46098	281-061	ROW	AR 1500 2007
F-18	29.65419	-98.44838	not located, under pavement (destroyed)	ROW	AR 682 2005
F18A	29.62919	-98.46098	281-061	ROW	AR 1500 2007
F18B	29.62943	-98.46060	281-061	ROW	AR 1500 2007
F19	29.63170	-98.45950	not located, under 281 pavement (destroyed)	ROW	AR 1500 2007
F-19	29.65458	-98.44864	non-karst closed depression	ROW	AR 682 2005
F20	29.63428	-98.45767	not located, under pavement (destroyed)	ROW	AR 1500 2007
F-20	29.65515	-98.45017	non-karst, animal burrow	ROW	AR 682 2005
F21	29.63548	-98.45691	281-106	ROW	AR 1500 2007
F-21	29.65598	-98.44918	not located, solution cavity	ROW	AR 682 2005
F-22	29.66006	-98.45043	281-083	ROW	AR 682 2005

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
F-23	29.65983	-98.45044	281-084	ROW	AR 682 2005
F-24	29.65879	-98.45000	281-075	ROW	AR 682 2005
F-25	29.65990	-98.45051	281-083	ROW	AR 682 2005
F34	29.64020	-98.45500	non-karst, collapse from road cut	ROW	AR 1500 2007
F35	29.63935	-98.45542	not located, developed (destroyed)	ROW	AR 1500 2007
F37	29.63023	-98.46045	not located, solution cavity	ROW	AR 1500 2007
F38	29.62948	-98.46079	281-063	ROW	AR 1500 2007
F39	29.62452	-98.46338	281-060	ROW	AR 1500 2007
F40	29.62242	-98.46454	not located, solution cavity	ROW	AR 1500 2007
F41	29.63428	-98.45768	not located, "artifact of road cut - manmade"	ROW	AR 1500 2007
F42	29.62009	-98.46517	281-104	ROW	AR 1500 2007
F43	29.61355	-98.46768	281-080	ROW	AR 1500 2007
F44	29.62894	-98.46158	not located, closed depression	ROW	AR 1500 2007
F52	29.62922	-98.46098	281-061	ROW	AR 1500 2007
F100	29.66026	-98.44993	281-069-75	ROW	AR 1500 2007
F101	29.65923	-98.45042	281-087	ROW	AR 1500 2007
F102	29.64396	-98.45303	281-082	ROW	AR 1500 2007
F200	29.68204	-98.45362	281-096	ROW	AR 1500 2007
F201	29.64322	-98.45372	non-karst closed depression	ROW	AR 1500 2007
MM-1	29.61868	-98.46551	281-056	ROW	AR 682 2005
MM-2	29.64029	-98.45409	non-karst, man-made trench	ROW	AR 682 2005
MM-2	29.64058	-98.45394	non-karst, trench	ROW	AR 528 2003
MM-3	29.64232	-98.45418	non-karst, sanitary sewer	ROW	AR 682 2005
MM-3	29.64235	-98.45419	non-karst, sanitary sewer	ROW	AR 528 2003
MM-4	29.64672	-98.45185	not located, non-karst per source, sanitary sewer	ROW	AR 682 2005
MM-5	29.64884	-98.45125	not located (removed/destroyed)	ROW	AR 682 2005
MM-7	29.64884	-98.45125	not located (removed/destroyed)	ROW	AR 682 2005
MM-8	29.64884	-98.45125	not located (removed/destroyed)	ROW	AR 682 2005
S-1	29.65880	-98.44997	281-075	ROW	AR 633 2004
S-1	29.63428	-98.45767	non-karst closed depression from road cut	ROW	Pape-Dawson Engineers, Inc. 2009
S-1	29.65443	-98.44859	non-karst closed	ROW	Escarpment

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
			depression		Environmental 2005
S-2	29.66006	-98.44987	281-073	ROW	AR 633 2004
S-2	29.63550	-98.45689	281-106	ROW	Pape-Dawson Engineers, Inc. 2009
S-2	29.64767	-98.45129	not located, solution cavity	ROW	Integrated Testing & Engineering Company 2003
S-2	29.65441	-98.44853	non-karst closed depression	ROW	Escarpment Environmental 2005
S-3	29.66025	-98.44993	281-071	ROW	AR 633 2004
S-3	29.66003	-98.44981	281-069 - 73	ROW	Pape-Dawson Engineers, Inc. 2009
S-3	29.64781	-98.45108	not located, non-karst per source, sanitary sewer	ROW	Integrated Testing & Engineering Company 2003
S-3	29.65600	-98.44916	not located, closed depression	ROW	Escarpment Environmental 2005
S-4	29.66001	-98.45049	281-081	ROW	AR 633 2004
S-4	29.65989	-98.45050	281-083, 84 & 85	ROW	Pape-Dawson Engineers, Inc. 2009
S-4	29.62678	-98.46125	281-116	ROW	Intec of San Antonio 2008b
S-4	29.64775	-98.45106	not located, non-karst per source, sanitary sewer	ROW	Integrated Testing & Engineering Company 2003
S-5	29.65985	-98.45049	281-083	ROW	AR 633 2004
S-5	29.65203	-98.45025	281-045	ROW	Pape-Dawson Engineers, Inc. 2009
S-5	29.65000	-98.45096	not located, solution cavity	ROW	Frost GeoSciences, Inc. 2008a
S-6	29.65959	-98.45044	281-086	ROW	AR 633 2004
S-6	29.65203	-98.45025	281-045	ROW	Pape-Dawson Engineers, Inc. 2009
S-6	29.65067	-98.45073	not located, solution cavity	ROW	Frost GeoSciences, Inc. 2008a
S-6	29.62678	-98.46125	281-116	ROW	Intec of San Antonio 2007
S-6	29.64747	-98.45203	not located, solution cavity	ROW	Integrated Testing & Engineering Company 2003
S-7	29.65924	-98.45046	281-087	ROW	AR 633 2004

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
S-7	29.65203	-98.45025	non-karst closed depression, stream scour	ROW	Pape-Dawson Engineers, Inc. 2009
S-8	29.64689	-98.45211	not located, non-karst per source, sanitary sewer	ROW	Pape-Dawson Engineers, Inc. 2009
S-8	29.64728	-98.45204	not located, solution cavity	ROW	Integrated Testing & Engineering Company 2003
S-9	29.64608	-98.45206	not located, solution fracture	ROW	Pape-Dawson Engineers, Inc. 2009
S-9	29.64728	-98.45204	not located, solution cavity	ROW	Integrated Testing & Engineering Company 2003
S-10	29.63450	-98.45811	281-081	ROW	Pape-Dawson Engineers, Inc. 2009
S-10	29.64667	-98.45175	not located, non-karst per source, sanitary sewer	ROW	Integrated Testing & Engineering Company 2003
S-11	29.62931	-98.46092	281-066	ROW	Pape-Dawson Engineers, Inc. 2009
S-11	29.64675	-98.45197	not located, non-karst per source, sanitary sewer	ROW	Integrated Testing & Engineering Company 2003
S-12	29.63967	-98.45522	not located, fault	ROW	Pape-Dawson Engineers, Inc. 2009
S-12	29.64675	-98.45199	not located, non-karst per source, culvert	ROW	Integrated Testing & Engineering Company 2003
S-13	29.63506	-98.45742	not located, fault	ROW	Pape-Dawson Engineers, Inc. 2009
S-13	29.64672	-98.45197	not located, non-karst per source, culvert	ROW	Integrated Testing & Engineering Company 2003
S-14	29.64053	-98.45403	non-karst closed depression	ROW	Pape-Dawson Engineers, Inc. 2009
S-14	29.64642	-98.45174	not located, non-karst per source, sanitary sewer lift station	ROW	Integrated Testing & Engineering Company 2003
S-15	29.64089	-98.45403	non-karst closed depression	ROW	Pape-Dawson Engineers, Inc. 2009
S-16	29.64247	-98.45322	281-077	ROW	Pape-Dawson Engineers, Inc.

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
					2009
S-16	29.65036	-98.44945	non-karst closed depression	ROW	Escarpment Environmental 2005
S-17	29.65422	-98.44842	non-karst closed depression	ROW	Pape-Dawson Engineers, Inc. 2009
S-18	29.62936	-98.46088	281-062	ROW	Pape-Dawson Engineers, Inc. 2009
S-19	29.64433	-98.45253	281-115	ROW	Pape-Dawson Engineers, Inc. 2009
S-20	29.65318	-98.44863	non-karst closed depression	ROW	Escarpment Environmental 2005
S-21	29.64986	-98.45022	not located, fault	ROW	Pape-Dawson Engineers, Inc. 2009
S-21	29.65334	-98.44852	not located, solution fracture	ROW	Escarpment Environmental 2005
S-22A	29.65417	-98.44835	not located, under pavement (destroyed)	ROW	Escarpment Environmental 2005
S-22B	29.65417	-98.44835	not located, under pavement (destroyed)	ROW	Escarpment Environmental 2005
S-22C	29.65417	-98.44835	not located, under pavement (destroyed)	ROW	Escarpment Environmental 2005
S-23A	29.65424	-98.44853	not located, area has been filled	ROW	Escarpment Environmental 2005
S-23B	29.65424	-98.44853	not located, area has been filled	ROW	Escarpment Environmental 2005
S-23C	29.65424	-98.44853	not located, area has been filled	ROW	Escarpment Environmental 2005
S-25	29.65437	-98.44866	non-karst closed depression	ROW	Escarpment Environmental 2005
S-26	29.65434	-98.44872	non-karst closed depression	ROW	Escarpment Environmental 2005
Tiny Town Sink			Reported destroyed in 1973	ROW	TSS 2010
C-Section Cave			appears to have been cleared, may be	500 ft buffer	TSS 2010

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
			removed (destroyed)		
F1	29.63878	-98.45456	no access - not located, developed (destroyed)	500 ft buffer	AR 1500 2007
F2	29.70027	-98.45099	281-099	500 ft buffer	AR 1500 2007
F-2	29.67849	-98.45388	no access - not located, solution cavity	500 ft buffer	AR 699 2005
F3	29.70147	-98.45077	281-004	500 ft buffer	AR 1500 2007
F-3	29.67859	-98.45388	no access - not located, sinkhole	500 ft buffer	AR 699 2005
F6	29.64953	-98.45160	281-043	500 ft buffer	AR 1500 2007
F7	29.64940	-98.45151	non-karst closed depression	500 ft buffer	AR 1500 2007
F7E	29.67537	-98.45145	no access - not located, other bedrock feature	500 ft buffer	AR 1500 2007
F8E	29.68303	-98.45285	281-033	500 ft buffer	AR 1500 2007
F11E C	29.70470	-98.44930	not located, fractured bedrock in creek	500 ft buffer	AR 1500 2007
F12E	29.69557	-98.45118	281-100	500 ft buffer	AR 1500 2007
F13E B	29.70873	-98.44854	not located, exposed bedrock	500 ft buffer	AR 1500 2007
F16	29.68789	-98.45325	no access - not located, sinkhole	500 ft buffer	AR 1500 2007
F18	29.69187	-98.45204	no access - not located, closed depression	500 ft buffer	AR 1500 2007
F19	29.70195	-98.45223	no access - not located, bulldozed/filled/trash	500 ft buffer	AR 1500 2007
F20	29.69292	-98.45326	281-014	500 ft buffer	AR 1500 2007
F20W	29.70561	-98.45107	281-098	500 ft buffer	AR 1500 2007
F21	29.68630	-98.45357	no access - not located, sinkhole	500 ft buffer	AR 1500 2007
F21W	29.70235	-98.45159	no access - not located, animal burrow	500 ft buffer	AR 1500 2007
F22	29.68335	-98.45438	no access - not located, bulldozer scar	500 ft buffer	AR 1500 2007
F223	29.62684	-98.46297	no access - not located, unknown	500 ft buffer	AR 1500 2007

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
F-23 cave	29.67847	-98.45393	no access - not located, cave	500 ft buffer	TSS 2010
F24	29.67921	-98.45397	no access - not located, solution cavity	500 ft buffer	AR 1500 2007
F25	29.67589	-98.45349	no access - not located, solution cavity	500 ft buffer	AR 1500 2007
F26	29.67581	-98.45350	no access - not located, solution enlarged fracture	500 ft buffer	AR 1500 2007
F28	29.66635	-98.44832	no access - not located, sinkhole/closed depression	500 ft buffer	AR 1500 2007
F29	29.65066	-98.45077	not located, solution fracture	500 ft buffer	AR 1500 2007
F2E	29.66683	-98.44909	no access - not located, septic tank	500 ft buffer	AR 1500 2007
F30	29.66536	-98.45040	no access - not located, closed depression/solution cavity	500 ft buffer	AR 1500 2007
F31	29.64772	-98.45231	non-karst, animal burrow	500 ft buffer	AR 1500 2007
F32	29.64769	-98.45276	non-karst closed depression	500 ft buffer	AR 1500 2007
F33	29.64344	-98.45394	no access - not located, solution cavity	500 ft buffer	AR 1500 2007
F36	29.64043	-98.45603	not located, developed (destroyed)	500 ft buffer	AR 1500 2007
F45	29.62965	-98.46148	no access - not located, solution cavity	500 ft buffer	AR 1500 2007
F46	29.62691	-98.46290	no access - not located, solution cavity	500 ft buffer	AR 1500 2007
F47	29.62684	-98.46297	no access - not located, cave	500 ft buffer	AR 1500 2007
F49	29.65259	-98.45114	not located, solution cavity	500 ft buffer	AR 1500 2007
F51	29.64852	-98.45205	no access - not located, solution cavity	500 ft buffer	AR 1500 2007
LineAStation11+30	29.64678	-98.45004	not located, filled (destroyed) per source	500 ft buffer	Frost GeoSciences, Inc. 2008d
LineAStation11+	29.64678	-98.45021	not located, filled (destroyed) per	500 ft buffer	Frost GeoSciences, Inc. 2008d

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
60			source		
S1-11	29.63934	-98.45375	not located, graded (destroyed)	500 ft buffer	Pape-Dawson Engineers, Inc. 2004
S1-84	29.63922	-98.45413	not located, graded (destroyed)	500 ft buffer	Pape-Dawson Engineers, Inc. 2004
S-1	29.63653	-98.45383	no access - not located, non-karst per source, culvert	500 ft buffer	DNA Geosciences, Inc. 2005
S-1	29.62997	-98.45786	no access - not located, non-karst per source	500 ft buffer	Intec of San Antonio 2008a
S-1	29.64058	-98.45369	non-karst, sanitary sewer	500 ft buffer	Pape-Dawson Engineers, Inc. 2008
S-1	29.67441	-98.45411	no access - not located, fractured bedrock	500 ft buffer	Frost GeoSciences, Inc. 2008c
S-1	29.61414	-98.46772	non-karst, sanitary sewer	500 ft buffer	Pape-Dawson Engineers, Inc. 2007a
S-1	29.63819	-98.45737	no access - not located, closed depression	500 ft buffer	Pape-Dawson Engineers, Inc. 2007b
S-1	29.63819	-98.45737	not located, non-karst per source, animal burrow	500 ft buffer	Pape-Dawson Engineers, Inc. 2007c
S-1	29.62736	-98.46047	no access - not located, fractured bedrock	500 ft buffer	Intec of San Antonio 2008b
S-1	29.62628	-98.46131	no access - not located, solution cavity	500 ft buffer	Intec of San Antonio 2007
S-1	29.64814	-98.45202	not located, solution cavity	500 ft buffer	Integrated Testing & Engineering Company 2003
S-1	29.66109	-98.44898	no access - not located, non-karst closed depression per source	500 ft buffer	Gulf Coast Compliance, Inc. 2007
S-1	29.64800	-98.44856	no access - not located, non-karst per source, man-made excavation	500 ft buffer	Frost GeoSciences, Inc. 2005a
S-1	29.63619	-98.45347	no access - not located, closed depression	500 ft buffer	Neathery Environmental 2007
S-1a	29.62628	-98.46131	no access - not located, non-karst per	500 ft buffer	Intec of San Antonio 2007

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
			source		
S-2	29.63000	-98.45783	no access - not located, non-karst per source	500 ft buffer	Intec of San Antonio 2008a
S-2	29.67281	-98.45236	no access - not located, solution cavity	500 ft buffer	Frost GeoSciences, Inc. 2008c
S-2	29.65025	-98.45213	non-karst, surficial vuggy rock	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-2	29.62772	-98.45983	no access - not located, non-karst per source	500 ft buffer	Intec of San Antonio 2008b
S-2	29.62717	-98.46072	no access - not located, fractured bedrock	500 ft buffer	Intec of San Antonio 2007
S-2	29.66139	-98.44888	no access - not located, non-karst closed depression per source	500 ft buffer	Gulf Coast Compliance, Inc. 2007
S-2	29.64806	-98.44936	no access - not located, fractured bedrock	500 ft buffer	Frost GeoSciences, Inc. 2005a
S-2	29.64720	-98.44929	no access - not located, fault	500 ft buffer	Frost GeoSciences, Inc. 2007
S-2	29.62258	-98.46270	no access - area is disturbed/developed (destroyed)	500 ft buffer	Duduit, T. J. 2005
S-3	29.68474	-98.45486	septic tank	500 ft buffer	Frost GeoSciences, Inc. 2009
S-3	29.67452	-98.45306	no access - not located, solution cavity	500 ft buffer	Frost GeoSciences, Inc. 2008c
S-3	29.61411	-98.47033	no access - not located, zone of non-karst closed depressions	500 ft buffer	Pape-Dawson Engineers, Inc. 2007a
S-3	29.65025	-98.45210	non-karst, surficial vuggy rock	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-3	29.62736	-98.46047	no access - not located, fractured bedrock	500 ft buffer	Intec of San Antonio 2007
S-3	29.66210	-98.44884	no access - not located, non-karst closed depression per source	500 ft buffer	Gulf Coast Compliance, Inc. 2007
S-3	29.64781	-98.44931	no access - not located, fractured bedrock	500 ft buffer	Frost GeoSciences, Inc. 2005a
S-3	29.62255	-98.46272	no access - area is disturbed/developed	500 ft buffer	Duduit, T. J. 2005

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
			(destroyed)		
S-4	29.68469	-98.45483	collapsed cellar	500 ft buffer	Frost GeoSciences, Inc. 2009
S-4	29.65025	-98.45213	non-karst, surficial vuggy rock	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-4	29.62772	-98.45983	no access - not located, non-karst per source	500 ft buffer	Intec of San Antonio 2007
S-4	29.66201	-98.44881	no access - not located, non-karst closed depression per source	500 ft buffer	Gulf Coast Compliance, Inc. 2007
S-4	29.64775	-98.44911	no access - not located	500 ft buffer	Frost GeoSciences, Inc. 2005a
S-4	29.65669	-98.44738	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-5	29.63919	-98.45737	no access - not located, fault	500 ft buffer	Pape-Dawson Engineers, Inc. 2007b
S-5	29.63919	-98.45737	no access - not located, fault	500 ft buffer	Pape-Dawson Engineers, Inc. 2007c
S-5	29.62572	-98.46133	no access - not located, non-karst per source	500 ft buffer	Intec of San Antonio 2007
S-5	29.64747	-98.45240	281-109	500 ft buffer	Integrated Testing & Engineering Company 2003
S-5	29.64744	-98.44925	no access - not located	500 ft buffer	Frost GeoSciences, Inc. 2005a
S-5	29.62252	-98.46278	no access - area is disturbed/developed (destroyed)	500 ft buffer	Duduit, T. J. 2005
S-6	29.66326	-98.44859	not located, cleared/graded (destroyed)	500 ft buffer	Pape-Dawson Engineers, Inc. 2002
S-6	29.62232	-98.46315	no access - area is disturbed/developed (destroyed)	500 ft buffer	Duduit, T. J. 2005
S-7	29.66336	-98.44870	281-037	500 ft buffer	Pape-Dawson Engineers, Inc. 2002
S-7	29.64975	-98.45132	281-097	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-7	29.64725	-98.45221	not located, solution cavity	500 ft buffer	Integrated Testing & Engineering Company 2003
S-7	29.64697	-98.44886	no access - not located, fractured	500 ft buffer	Frost GeoSciences, Inc. 2005a

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
			bedrock		
S-7	29.64720	-98.44916	no access - not located, fractured bedrock	500 ft buffer	Frost GeoSciences, Inc. 2005b
S-7	29.62222	-98.46338	no access - area is disturbed/developed (destroyed)	500 ft buffer	Duduit, T. J. 2005
S-7	29.65443	-98.44761	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-8	29.66314	-98.44956	not located, under pavement (destroyed)	500 ft buffer	Pape-Dawson Engineers, Inc. 2002
S-8	29.66077	-98.45050	not located, well	500 ft buffer	Frost GeoSciences, Inc. 2008b
S-8	29.64309	-98.45537	no access - not located, developed (destroyed)	500 ft buffer	Pape-Dawson Engineers, Inc. 2007b
S-8	29.64967	-98.45171	non-karst, surficial vuggy rock	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-8	29.64711	-98.44944	no access - not located, fractured bedrock	500 ft buffer	Frost GeoSciences, Inc. 2005a
S-8	29.62223	-98.46338	no access - area is disturbed/developed (destroyed)	500 ft buffer	Duduit, T. J. 2005
S-8	29.65555	-98.44866	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-9	29.66197	-98.45061	not located, man-made feature per source	500 ft buffer	Frost GeoSciences, Inc. 2008b
S-9	29.62544	-98.45800	no access - not located, other bedrock feature	500 ft buffer	Intec of San Antonio 2008a
S-9	29.64953	-98.45157	281-043	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-9	29.65612	-98.44879	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-10	29.64939	-98.45143	non-karst closed depression	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-10	29.64987	-98.44923	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-11	29.62572	-98.46133	no access - not located, other bedrock feature	500 ft buffer	Intec of San Antonio 2008a
S-11	29.64959	-98.45174	non-karst, animal burrow	500 ft buffer	Frost GeoSciences, Inc. 2008a

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
S-11	29.64973	-98.44936	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-11a	29.62572	-98.46133	no access - not located, closed depression	500 ft buffer	Intec of San Antonio 2008a
S-12	29.62628	-98.46131	no access - not located, solution cavity	500 ft buffer	Intec of San Antonio 2008a
S-12	29.64678	-98.44928	281-115	500 ft buffer	Frost GeoSciences, Inc. 2005a
S-12	29.64720	-98.44929	no access - not located, fault	500 ft buffer	Frost GeoSciences, Inc. 2005b
S-12	29.64929	-98.44867	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-13	29.64937	-98.44853	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-14	29.65117	-98.45068	not located, solution cavity	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-14	29.64952	-98.44863	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-15	29.65117	-98.45068	non-karst, surficial vuggy rock	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-15	29.65039	-98.44905	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-16	29.65284	-98.45032	not located, solution cavity	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-18	29.65157	-98.44806	not located, under pavement (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-19	29.65252	-98.44839	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-24	29.65452	-98.44815	no access - not located, developed (destroyed)	500 ft buffer	Escarpment Environmental 2005
S-30	29.67381	-98.45196	no access - not located, fractured bedrock	500 ft buffer	Frost Environmental 2003
S-31	29.65628	-98.45124	281-103	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-31	29.67372	-98.45254	no access - not located, solution cavity	500 ft buffer	Frost Environmental 2003
S-32	29.67147	-98.45216	no access - not located, solution	500 ft buffer	Frost Environmental

Historic ID	Latitude (NAD83)	Longitude (NAD 83)	Status and Description	Location	Source
			cavity		2003
S-33	29.65645	-98.45102	281-046	500 ft buffer	Frost GeoSciences, Inc. 2008a
S-33	29.67089	-98.45196	no access - not located, solution cavity	500 ft buffer	Frost Environmental 2003
S-34	29.67089	-98.45149	no access - not located, cave	500 ft buffer	Frost Environmental 2003
S-35	29.67186	-98.45129	no access - not located, solution cavity	500 ft buffer	Frost Environmental 2003
S-36	29.67300	-98.45378	no access - not located, solution cavity	500 ft buffer	Frost Environmental 2003
S-37	29.67314	-98.45378	no access - not located, solution cavity	500 ft buffer	Frost Environmental 2003
S-42	29.67450	-98.45433	no access - not located, surficial vuggy outcrop	500 ft buffer	Frost Environmental 2003
S-43	29.67425	-98.45381	no access - not located, fractured bedrock	500 ft buffer	Frost Environmental 2003
S-44	29.67147	-98.45216	no access - not located, solution cavity	500 ft buffer	Frost Environmental 2003
S-45	29.67394	-98.45306	no access - not located, solution cavity	500 ft buffer	Frost Environmental 2003
S-46	29.67372	-98.45417	no access - not located, fractured bedrock	500 ft buffer	Frost Environmental 2003
S-100	29.63819	-98.45764	not located, non-karst per source, sanitary sewer	500 ft buffer	Pape-Dawson Engineers, Inc. 2007c
SPRE	29.70876	-98.44871	not located, spring	500 ft buffer	AR 1500 2007
Voight Cave No. 1			appears to be under pavement (destroyed)	500 ft buffer	TSS 2010

Texas Speleological Survey Biology Records

The TSS database contains biology records on a total of three caves occurring within the study area that were not located. These caves are either destroyed or located on property where access was not granted. Below is a list of the caves and any other information included in the database.

Tiny Town Sink

TSS ID: BEX0073

Reported destroyed by road construction.

KINGDOM: ANIMALIA
PHYLUM: ARTHROPODA
SUPERCLASS: CHELICERATA
CLASS: ARACHNIDA
Order: Opiliones (opilionids)
Suborder: Palpatores
Family: Sclerosomatidae (harvestmen)
Subfamily: Gagrellinae
**Leiobunum townsendii* Weed
SUPERCLASS: HEXAPODA
CLASS: INSECTA
Order: Orthoptera (grasshoppers, crickets, and katydids)
Family: Rhaphidophoridae (camel and true cave crickets)
Ceuthophilus sp.

C-Section Cave [2 records]
TSS ID: BEX0159

Status unknown.

KINGDOM: ANIMALIA
PHYLUM: ARTHROPODA
SUPERCLASS: CHELICERATA
CLASS: ARACHNIDA
Order: Opiliones (opilionids)
Suborder: Palpatores
Family: Sclerosomatidae (harvestmen)
Subfamily: Gagrellinae
**Leiobunum townsendii* Weed
SUPERCLASS: HEXAPODA
CLASS: INSECTA
Order: Orthoptera (grasshoppers, crickets, and katydids)
Family: Rhaphidophoridae (camel and true cave crickets)
Ceuthophilus sp.

Pick-up Sticks Cave [11 records]
TSS ID: BEX0050

Status unknown.

KINGDOM: ANIMALIA
PHYLUM: MOLLUSCA
CLASS: GASTROPODA
Undetermined material
PHYLUM: ANNELIDA
CLASS: CLITELLATA
Order: Haplotaxida
Undetermined material
PHYLUM: ARTHROPODA
SUPERCLASS: CRUSTACEA

CLASS: MALACOSTRACA
SUBCLASS: EUMALACOSTRACA
Order: Isopoda
Suborder: Oniscoidea
Family: Armadillididae
Armadillidium vulgare (Latreille)
SUPERCLASS: CHELICERATA
CLASS: ARACHNIDA
Order: Acarina (mites and ticks)
Suborder: Prostigmata
Family: Leeuwenhoekiidae
?*Ceuthothrombium* sp.
SUPERCLASS: HEXAPODA
CLASS: COLLEMBOLA (springtails)
Order: Entomobryomorpha
Family: Entomobryidae (slender springtails)
Coecobrya caeca (Schött)
CLASS: INSECTA
Order: Zygentoma (silverfish and allies)
Family: Nicoletiidae (subterranean silverfish)
Texoreddellia spp. (troglobite)
Order: Orthoptera (grasshoppers, crickets, and katydids)
Family: Rhaphidophoridae (camel and true cave crickets)
Ceuthophilus sp.
Order: Coleoptera (beetles)
Undetermined material
Suborder: Polyphaga
Family: Staphylinidae (rove beetles)
Erichsonius sp.
Eustilicus condei (Jarrige)
Neobisnius sp.

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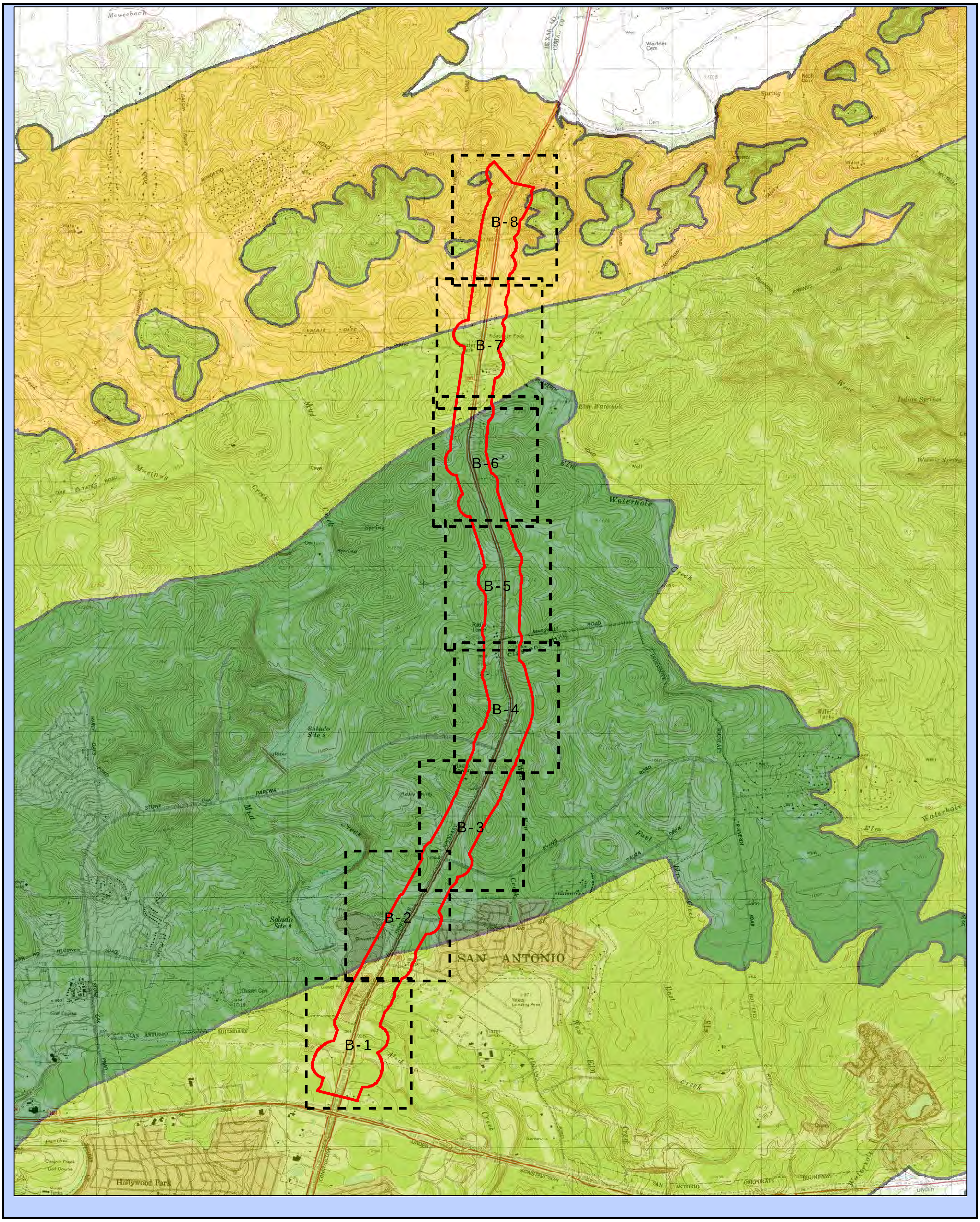
DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX B

RIGHT OF ENTRY IDENTIFICATION MAPS



Appendix B-Overview Map

Draft

Karst Zones data source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

ZARA ENVIRONMENTAL LLC

Study Area
plate extents

Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species probably occur
Zone 3 - Endangered species may occur
Zone 4 - Endangered species probably do not occur

Kilometers
0 1 2 4

0 0.5 1 2 3
Miles

N
W E
S

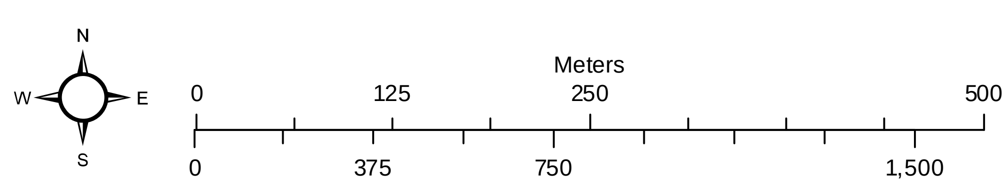
B-1, Right of Entry Map

DRAFT

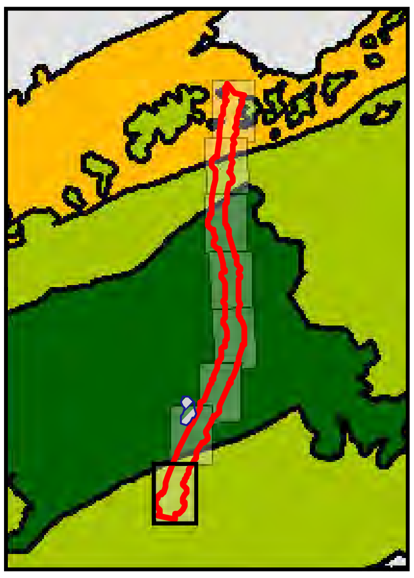
Right of Entry data source: Jacobs Engineering, 2010
Aerial data source: Bexar County Appraisal District, 2009

Study Area
plate extents
Critical habitiat Unit

Property R.O.E. Status
Yes
No
No Response



ZARA ENVIRONMENTAL LLC



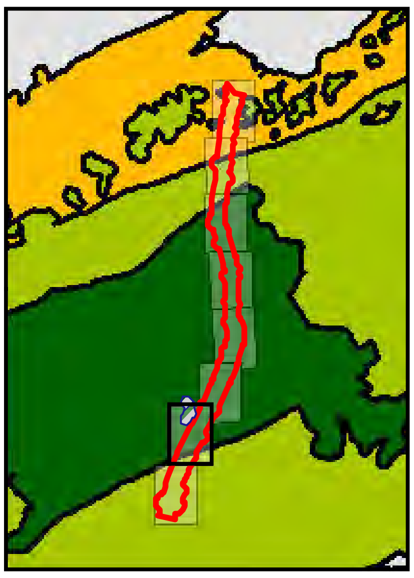
B-2, Right of Entry Map

DRAFT

Right of Entry data source: Jacobs Engineering, 2010
Aerial data source: Bexar County Appraisal District, 2009

Study Area
plate extents
Critical habitiat Unit

Property R.O.E. Status
Yes
No
No Response

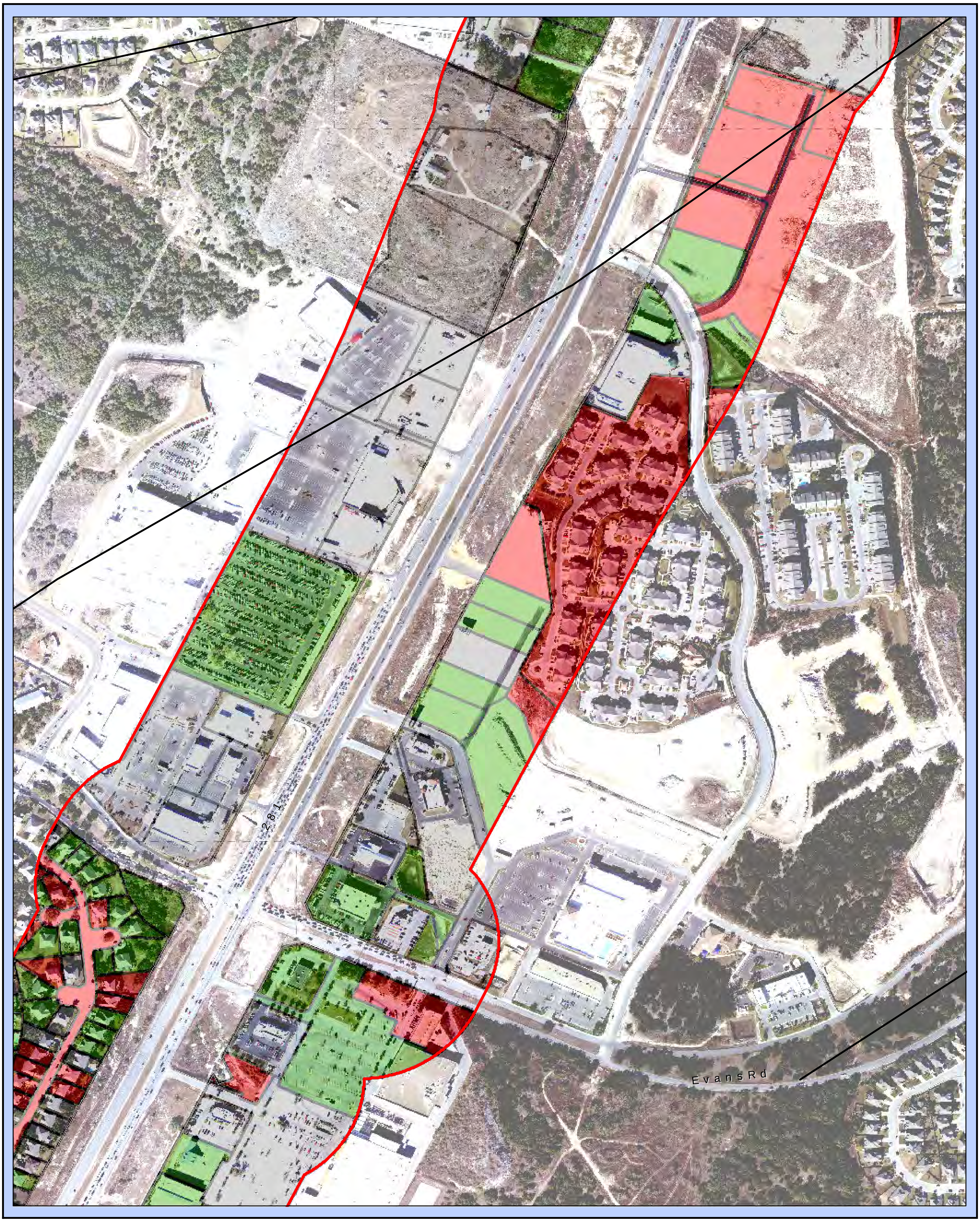


N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC



B-3, Right of Entry Map

DRAFT

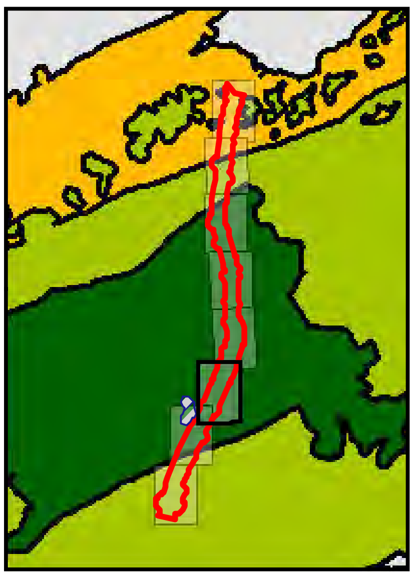
Right of Entry data source: Jacobs Engineering, 2010
Aerial data source: Bexar County Appraisal District, 2009

Study Area
plate extents
Critical habitiat Unit

Property R.O.E. Status
Yes
No
No Response

N
W E
S

Meters
0 125 250 500
0 375 750 1,500
Feet



ZARA
ENVIRONMENTAL LLC

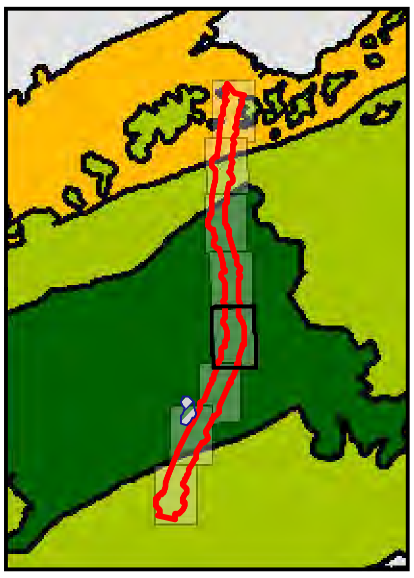
B-4, Right of Entry Map

DRAFT

Right of Entry data source: Jacobs Engineering, 2010
Aerial data source: Bexar County Appraisal District, 2009

Study Area
plate extents
Critical habitiat Unit

Property R.O.E. Status
Yes
No
No Response



N
W E
S

Meters
0 125 250 500
0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC

B-5, Right of Entry Map

DRAFT

Right of Entry data source: Jacobs Engineering, 2010
Aerial data source: Bexar County Appraisal District, 2009

- Study Area
- plate extents
- Critical habitiat Unit

Property R.O.E. Status

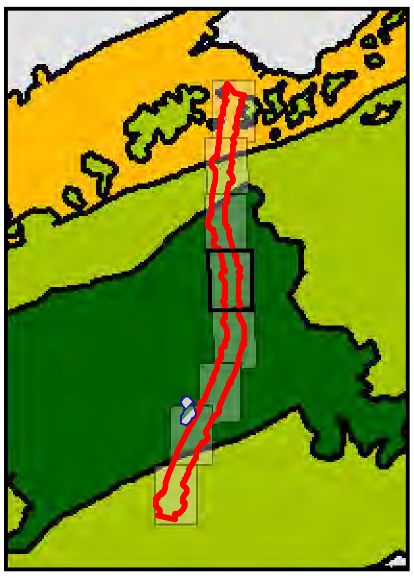
- Yes
- No
- No Response

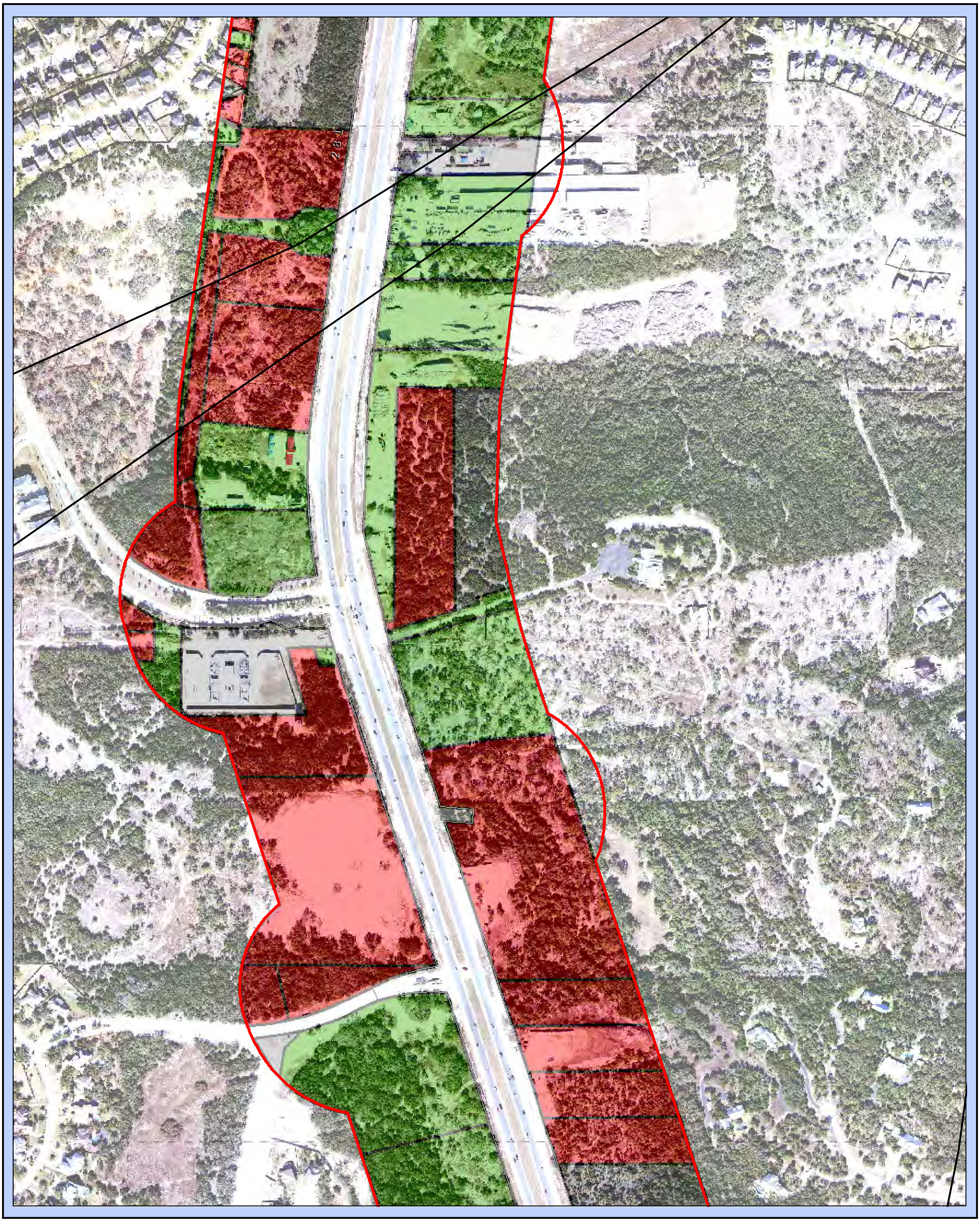
N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC

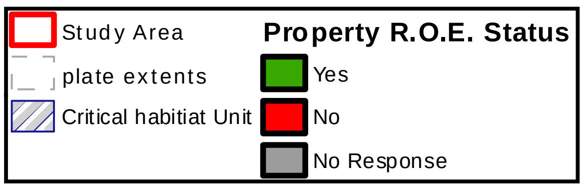


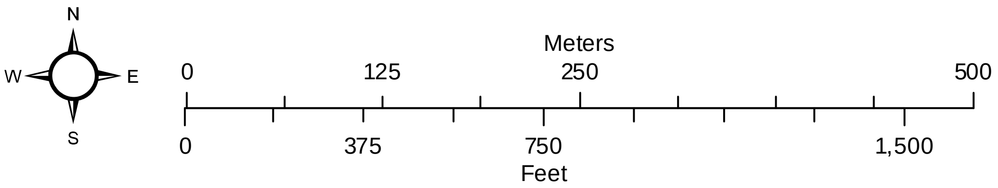


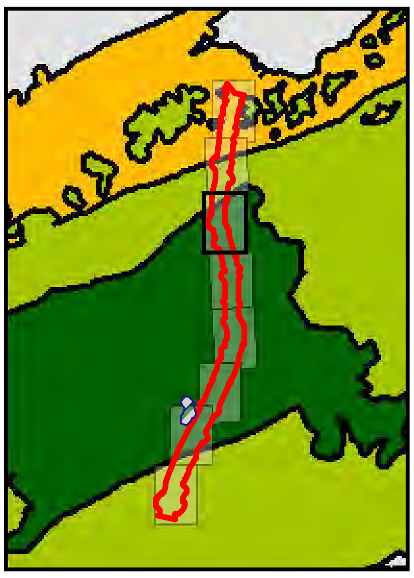
B-6, Right of Entry Map

DRAFT

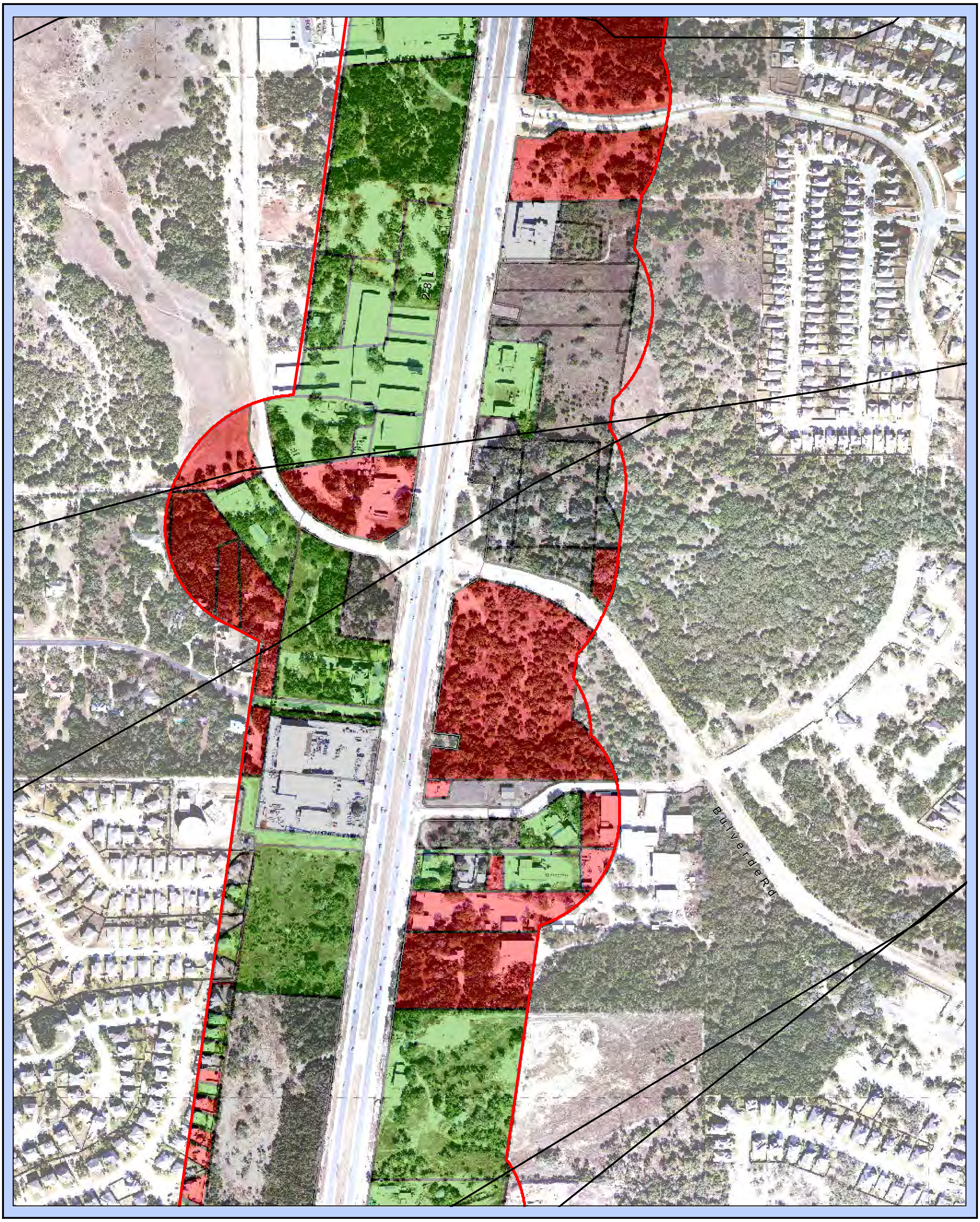
Right of Entry data source: Jacobs Engineering, 2010
Aerial data source: Bexar County Appraisal District, 2009







ZARA ENVIRONMENTAL LLC



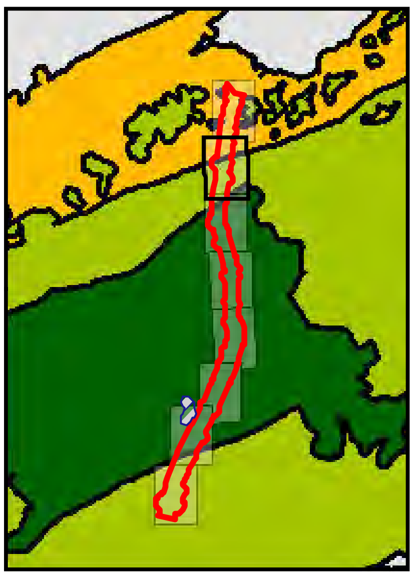
B-7, Right of Entry Map

DRAFT

Right of Entry data source: Jacobs Engineering, 2010
Aerial data source: Bexar County Appraisal District, 2009

Study Area
plate extents
Critical habitiat Unit

Property R.O.E. Status
Yes
No
No Response



N W E S

Meters
0 125 250 500
0 375 750 1,500
Feet

ZARA ENVIRONMENTAL LLC

B-8, Right of Entry Map

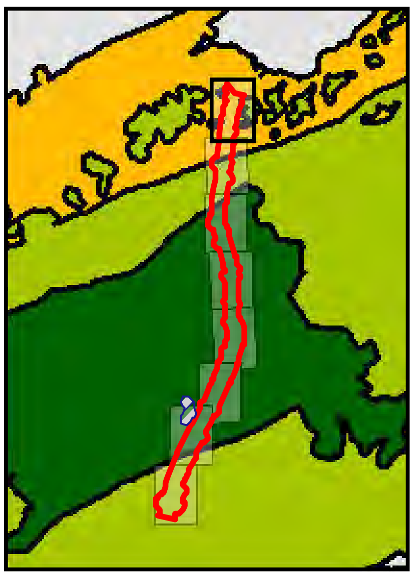
DRAFT

Right of Entry data source: Jacobs Engineering, 2010
Aerial data source: Bexar County Appraisal District, 2009

Study Area
plate extents
Critical habitiat Unit

Property R.O.E. Status

- Yes
- No
- No Response



N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC

DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX C

FEATURE SKETCHES

Field sketches of features encountered during karst feature surveys

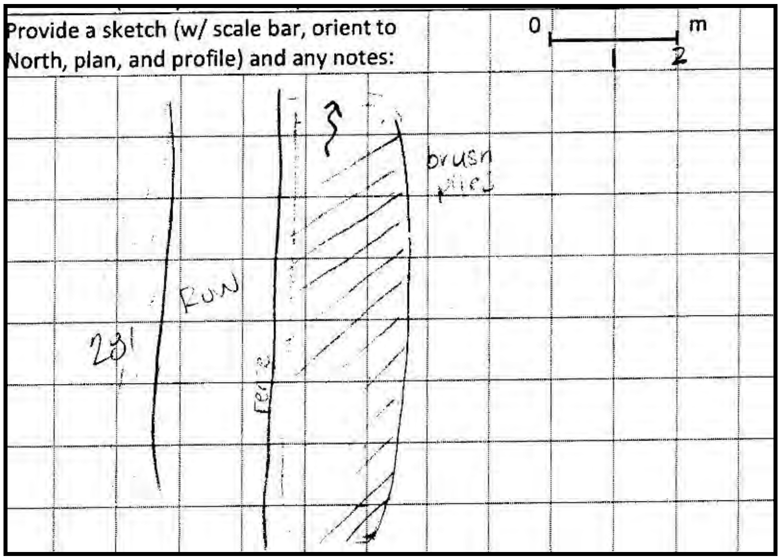


Figure 1. Field sketch of feature 281-002

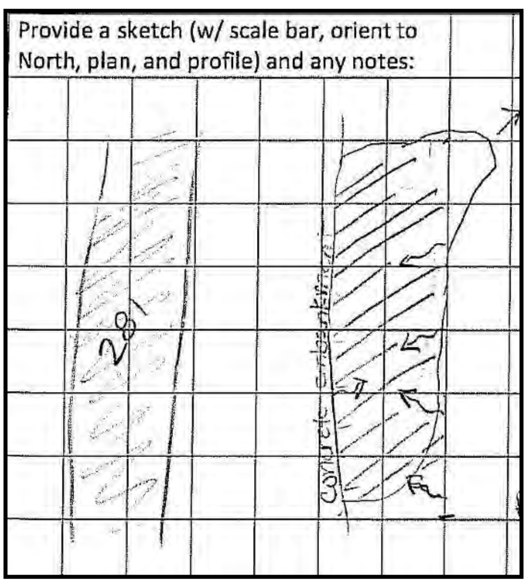


Figure 2. Field sketch of feature 281-003; 1 square = 1 meter

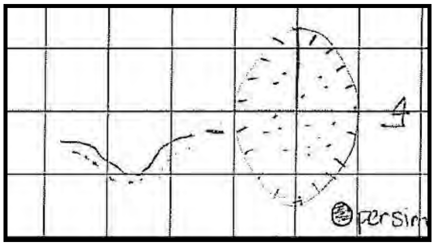


Figure 3. Field sketch of feature 281-004; 1 square = 0.25 m.

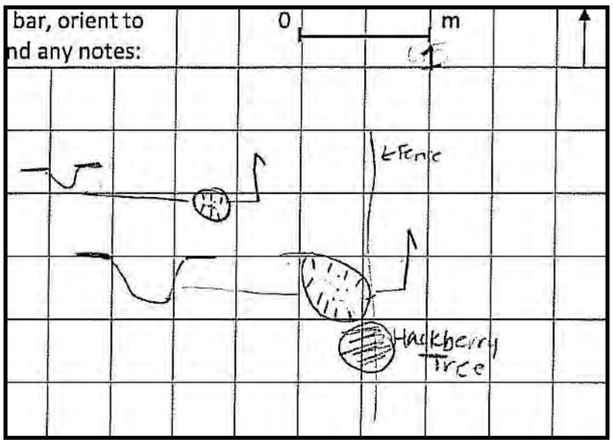


Figure 4. Field sketch of feature 281-005.

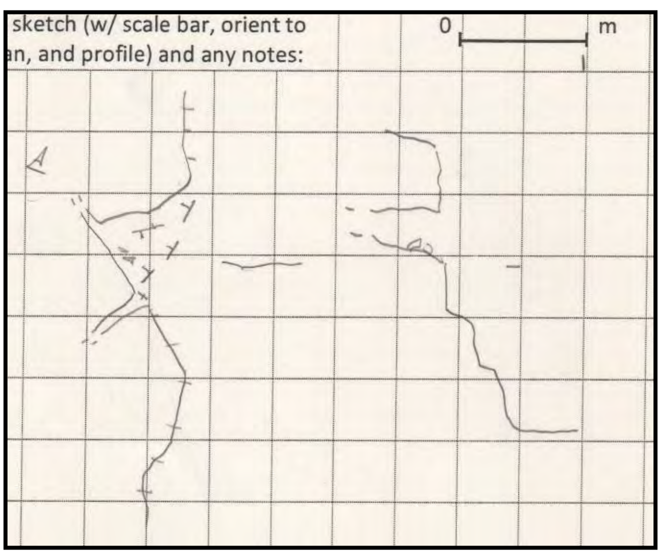


Figure 5. Field sketch of feature 281-006.

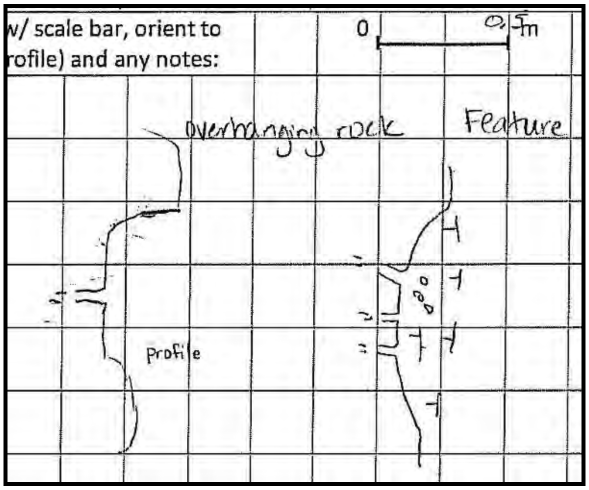


Figure 6. Field sketch of feature 281-007.

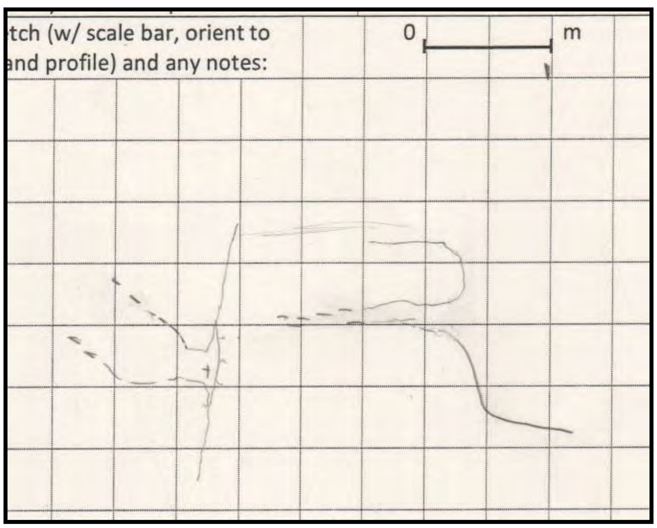


Figure 7. Field sketch of feature 281-008.

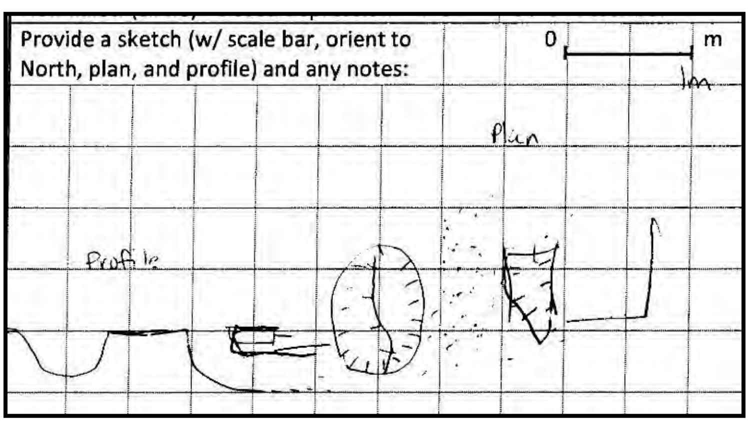


Figure 8. Field sketch of feature 281-009.

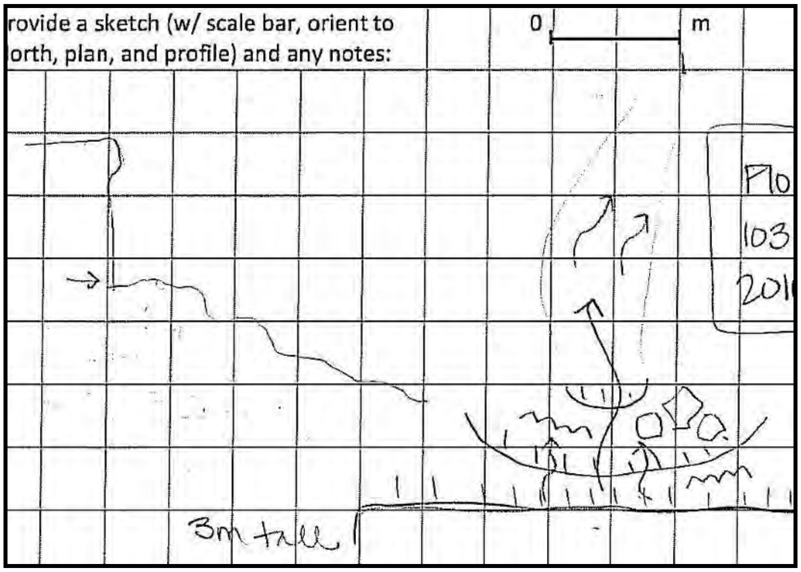


Figure 9. Field sketch of feature 281-010.

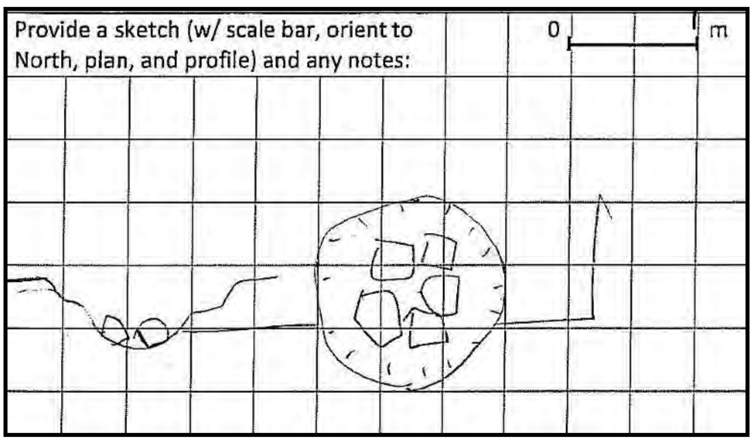


Figure 10. Field sketch of feature 281-011.

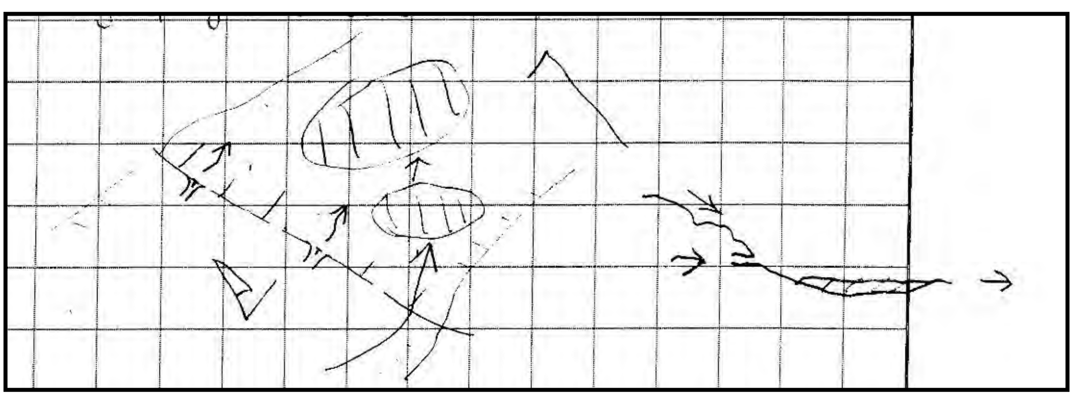


Figure 11. Field sketch of feature 281-012; 1 square = 1 meter.

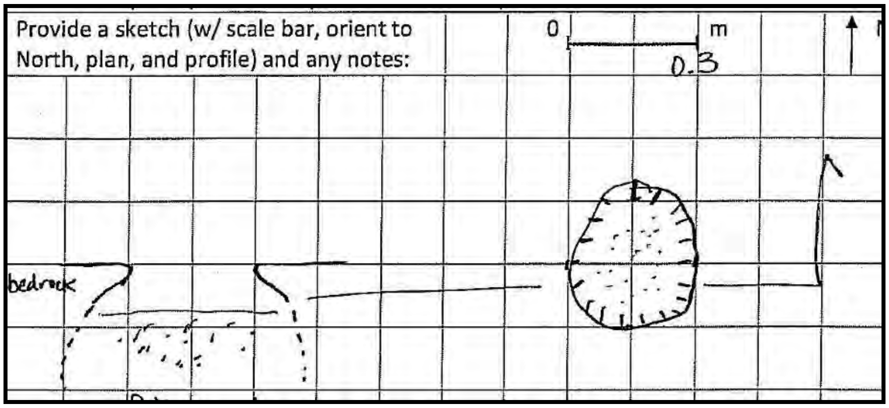


Figure 12. Field sketch of feature 281-013.

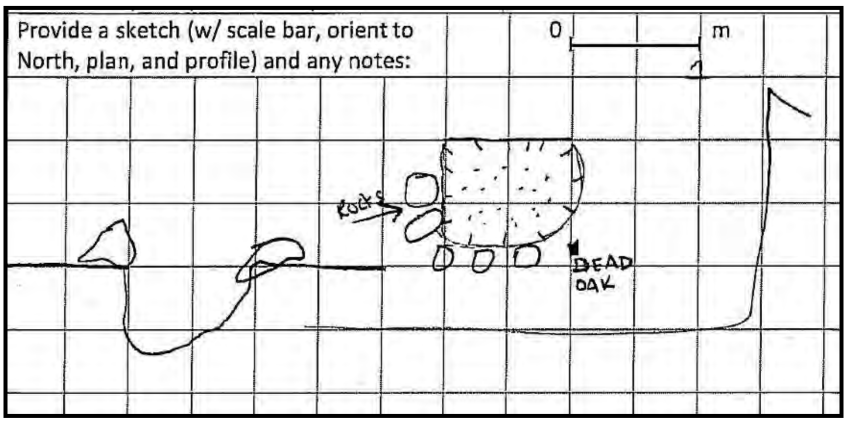


Figure 13. Field sketch of feature 281-014.

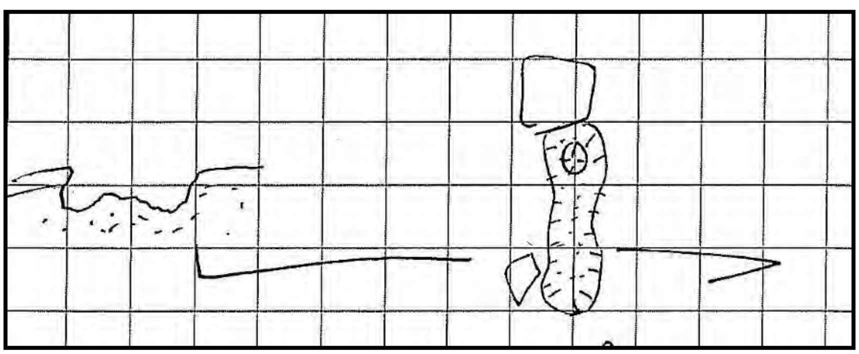


Figure 14. Field sketch of feature 281-015; 1 square = 0.5 m.

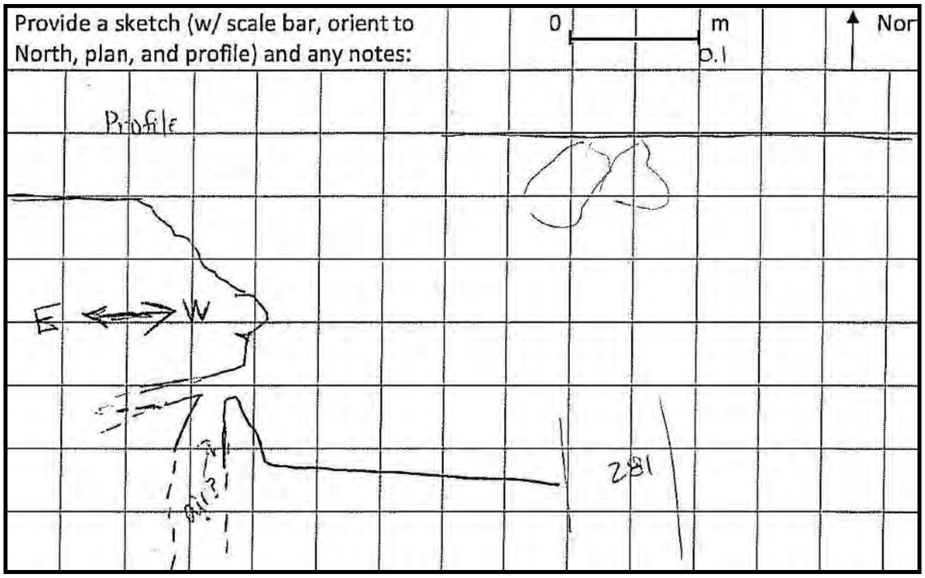


Figure 15. Field sketch of feature 281-016.

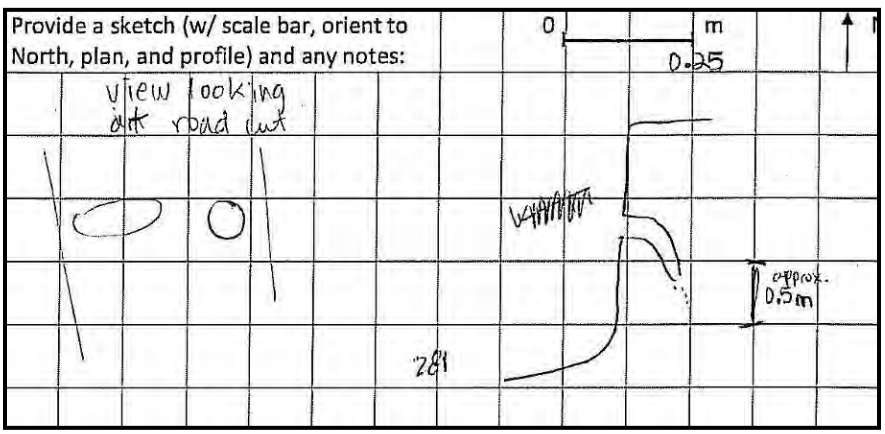


Figure 16. Field sketch of feature 281-017.

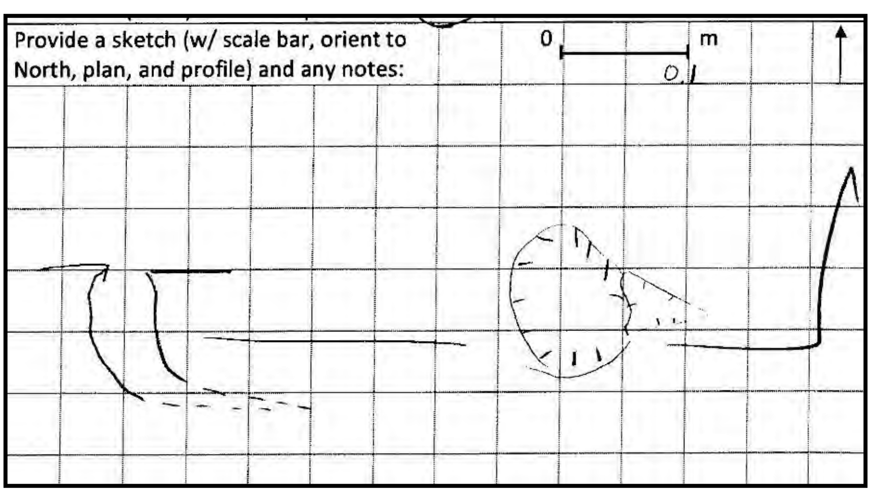


Figure 17. Field sketch of feature 281-020.

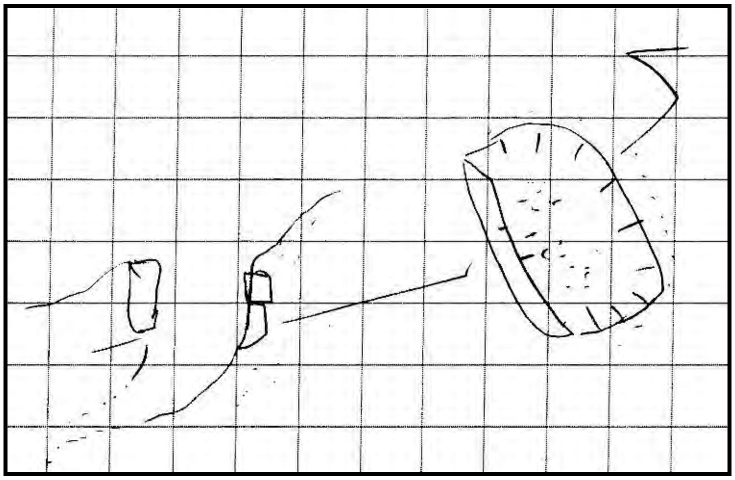


Figure 18. Field sketch of feature 281-021.

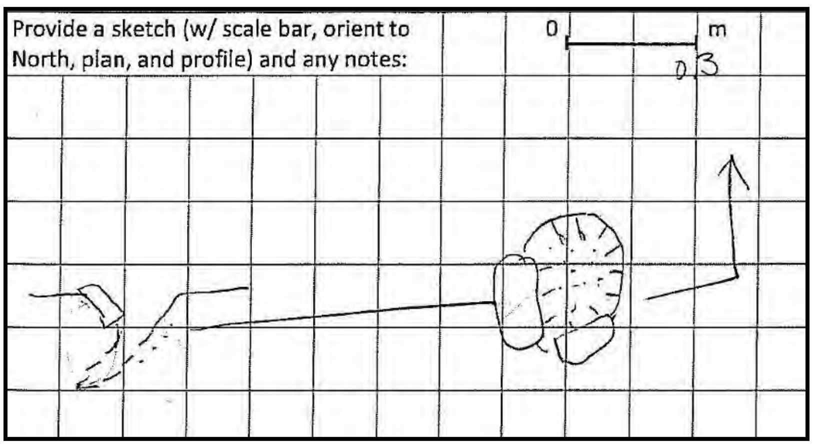


Figure 19. Field sketch of feature 281-024.

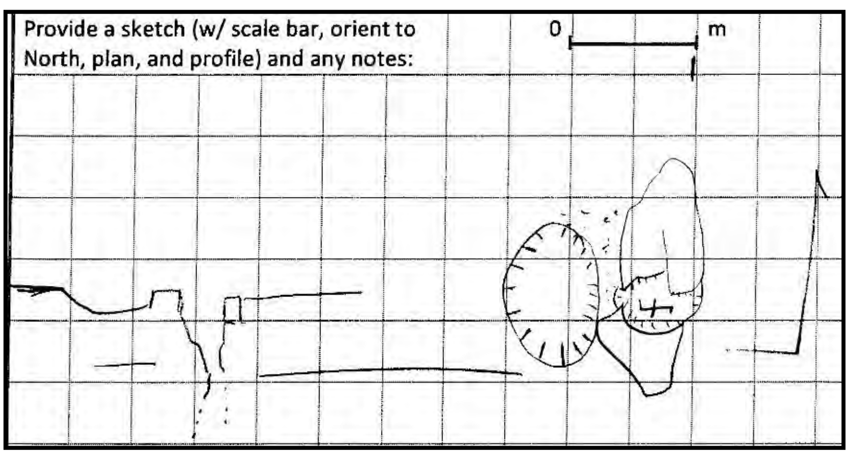


Figure 20. 281-026.

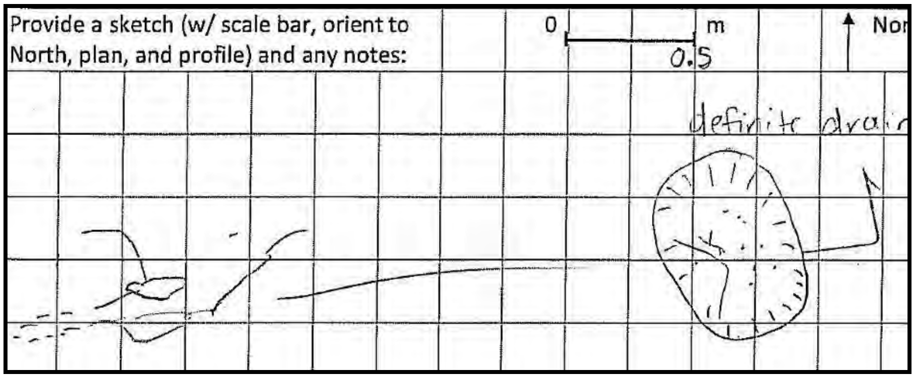


Figure 21. 281-029.

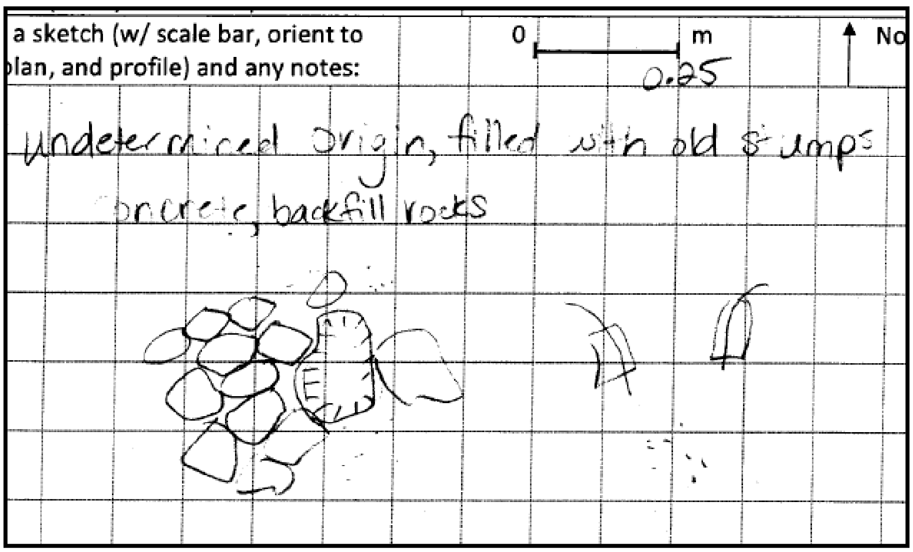


Figure 22. 281-030.

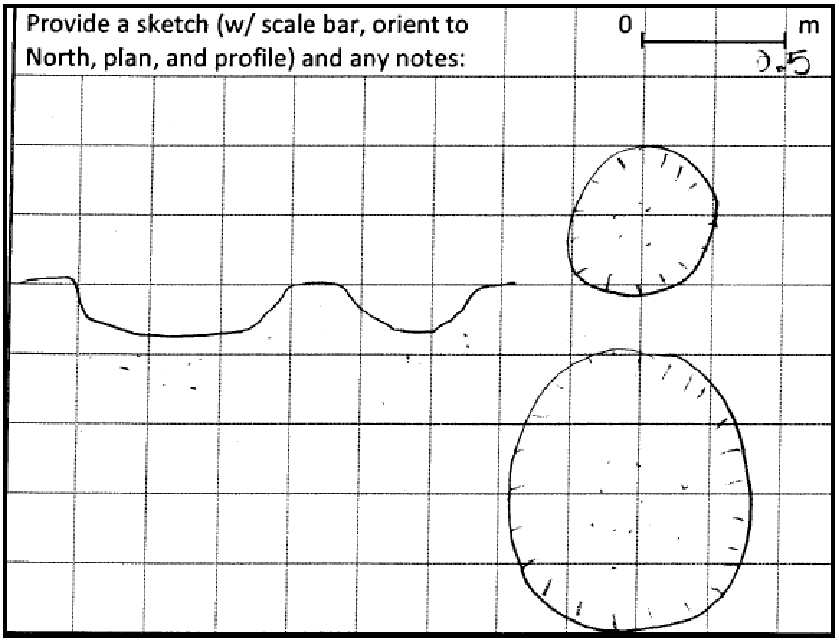


Figure 23. 281-031.

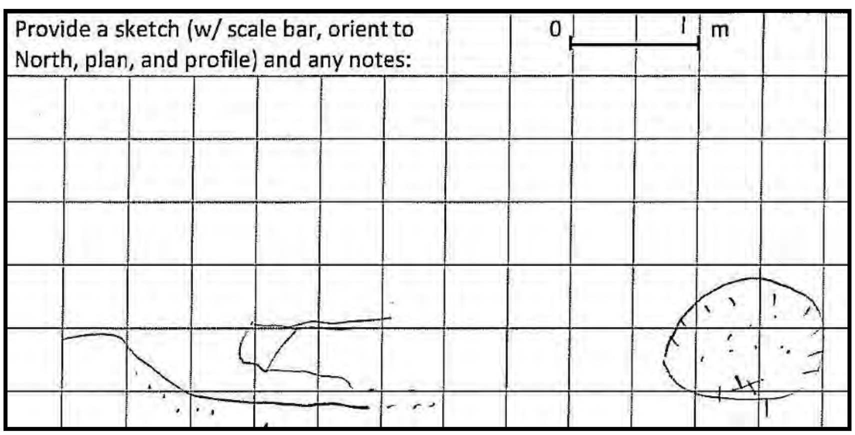


Figure 24. 281-032.

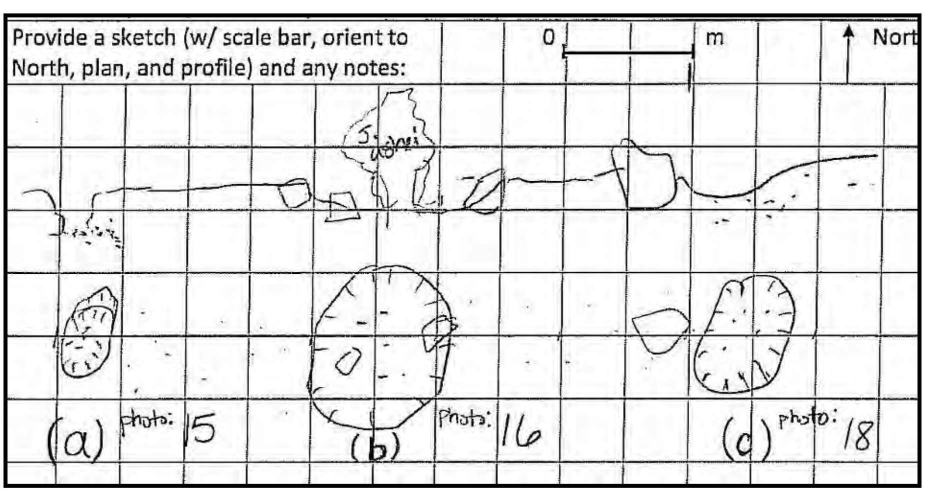


Figure 25. 281-035.

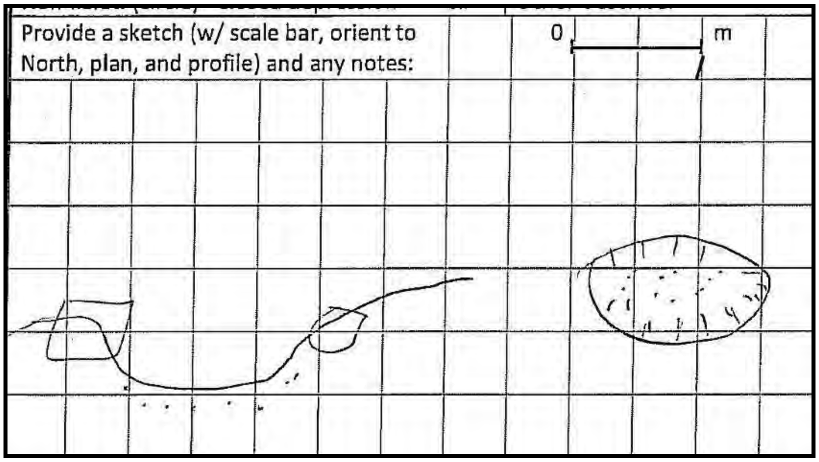


Figure 26. 281-036.

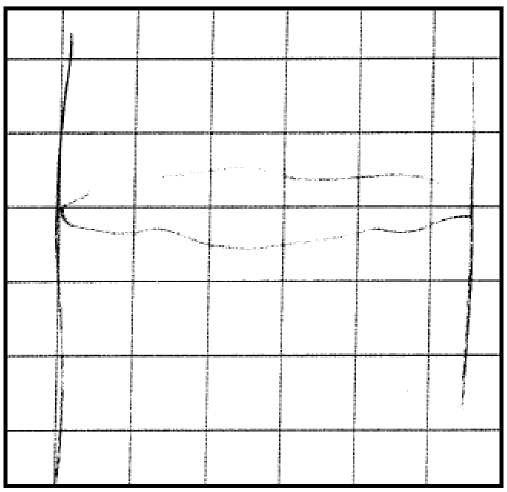


Figure 27. 281-037.

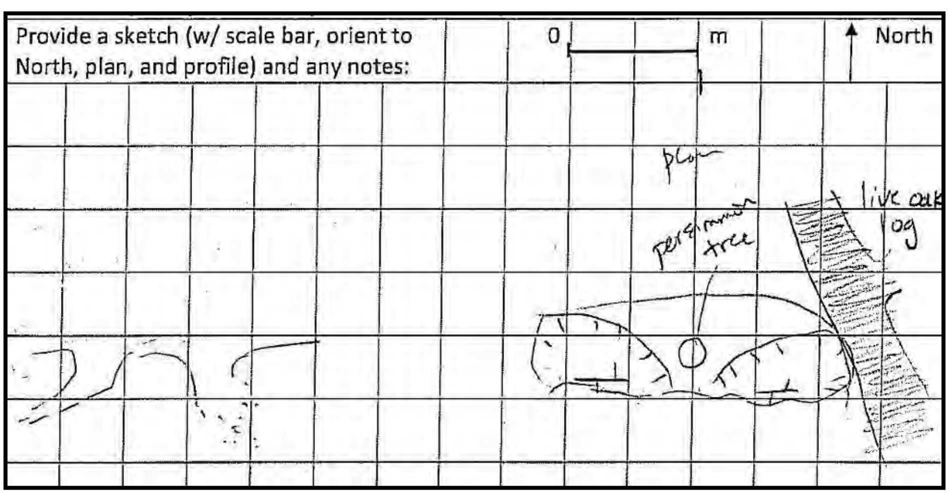


Figure 28. 281-038.

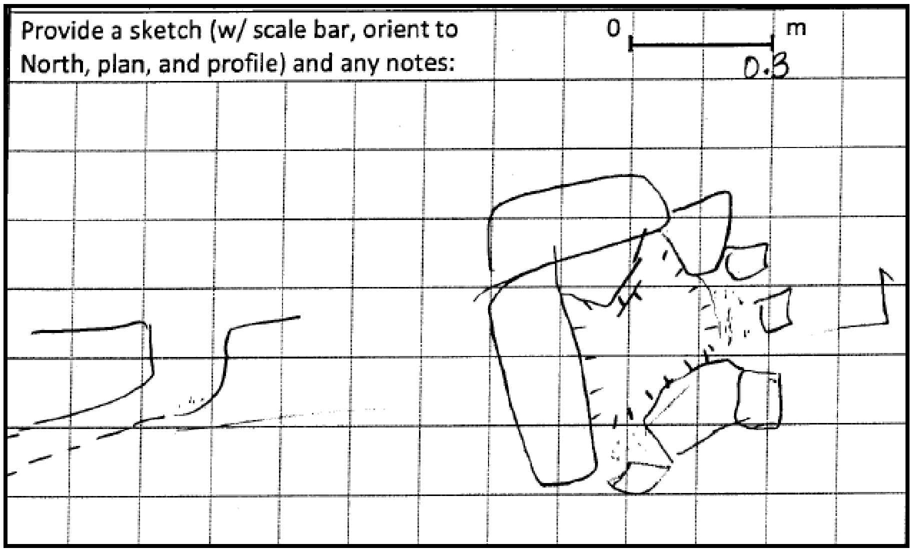


Figure 29. 281-039.

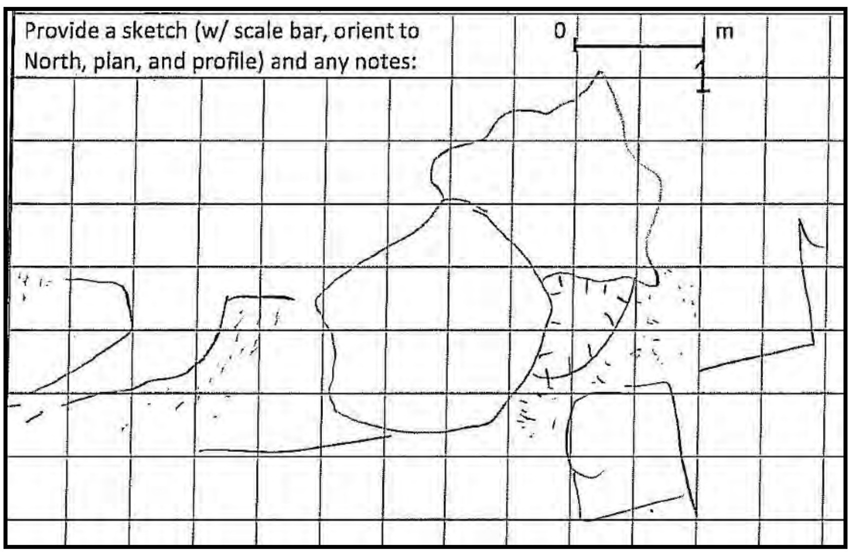


Figure 30. 281-040.

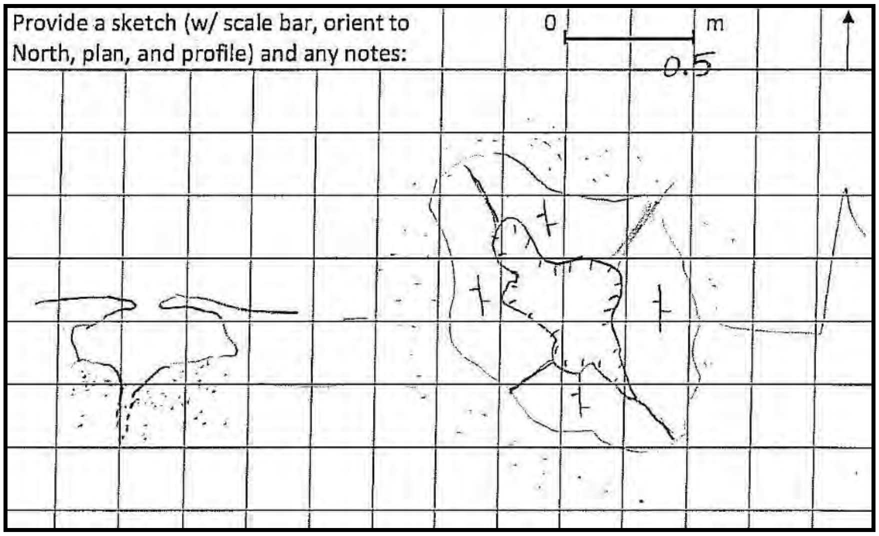


Figure 31. 281-041.

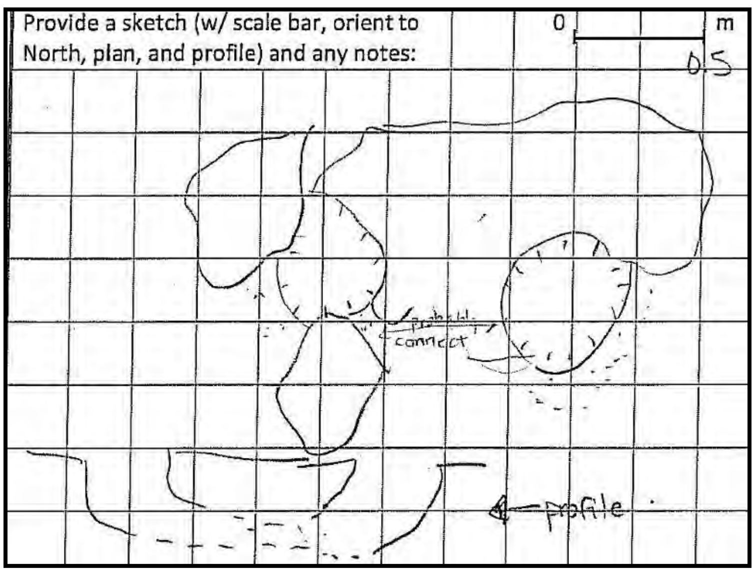


Figure 32. 281-042.

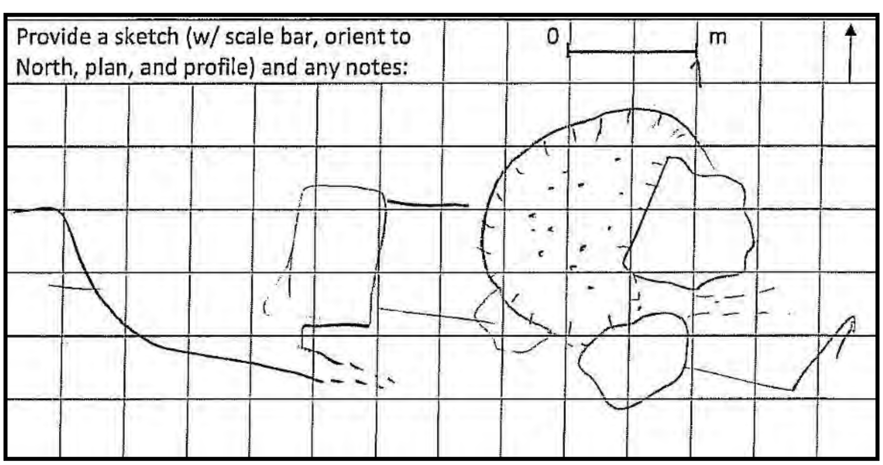


Figure 33. 281-043.

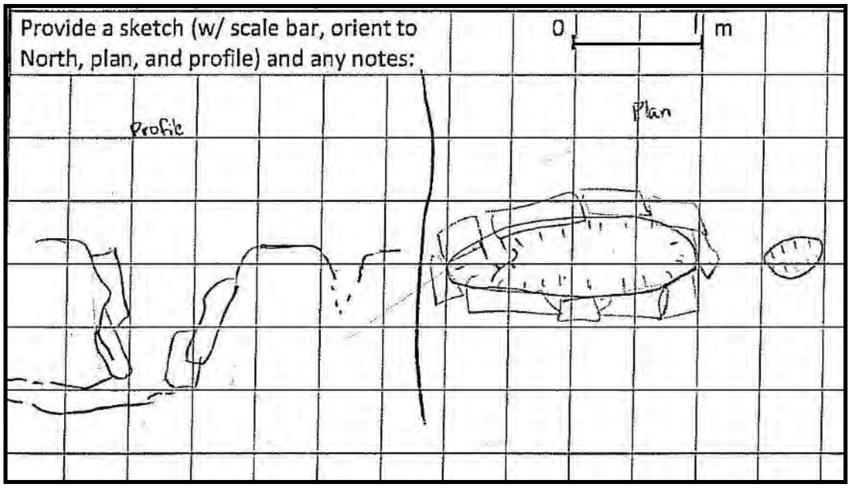


Figure 34. 281-044.

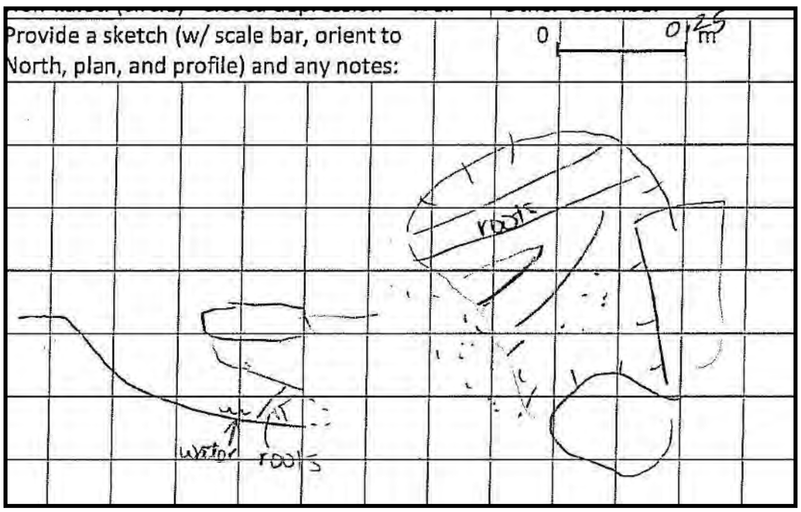


Figure 35. 281-046.

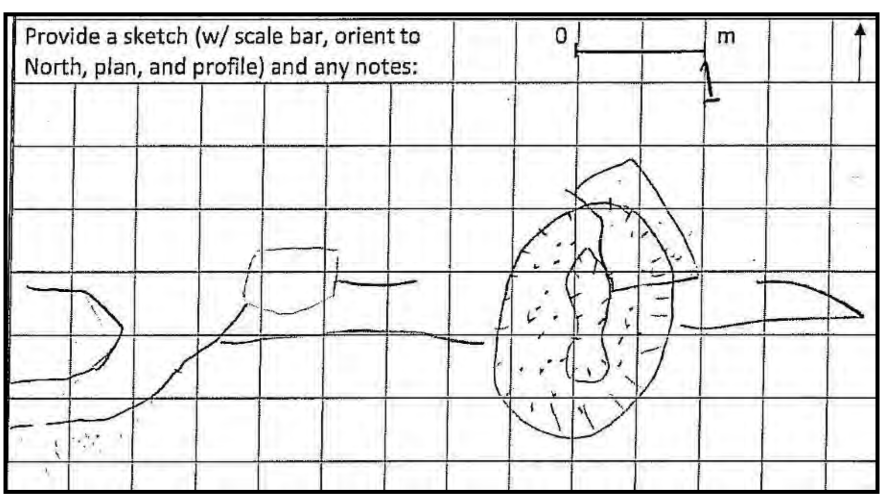


Figure 36. 281-047.

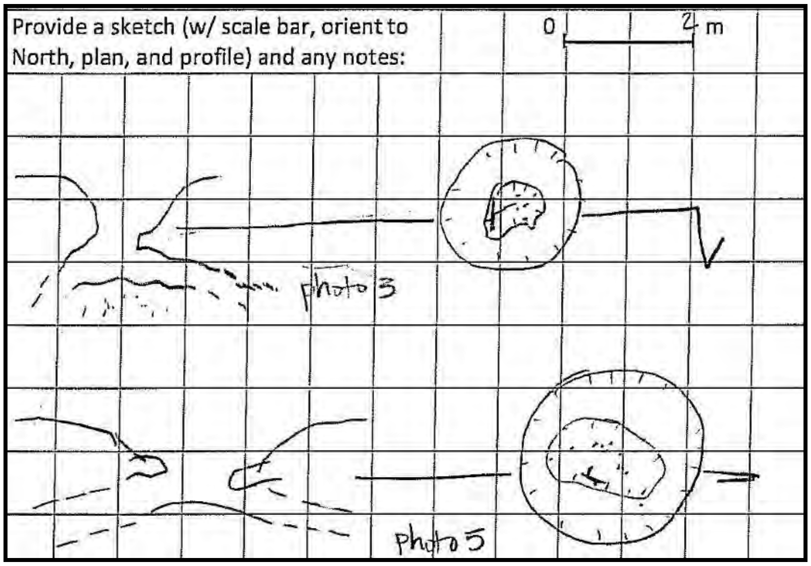


Figure 37. 281-048.

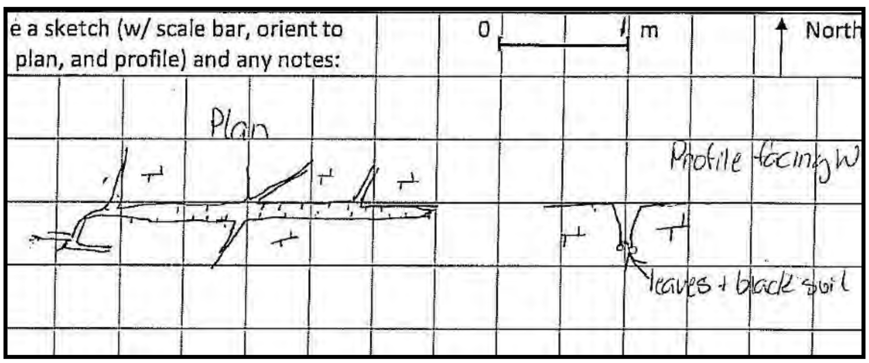


Figure 38. 281-051.

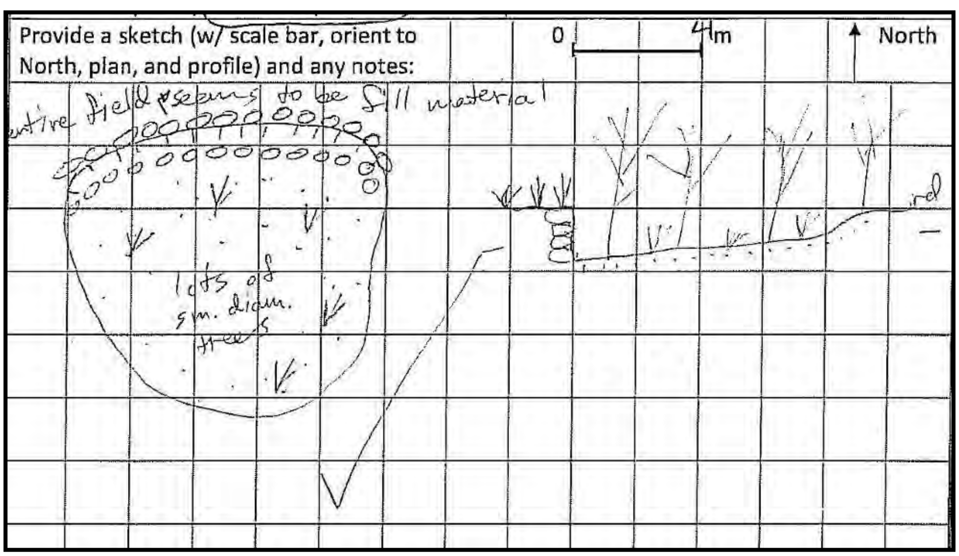


Figure 39. 281-052.

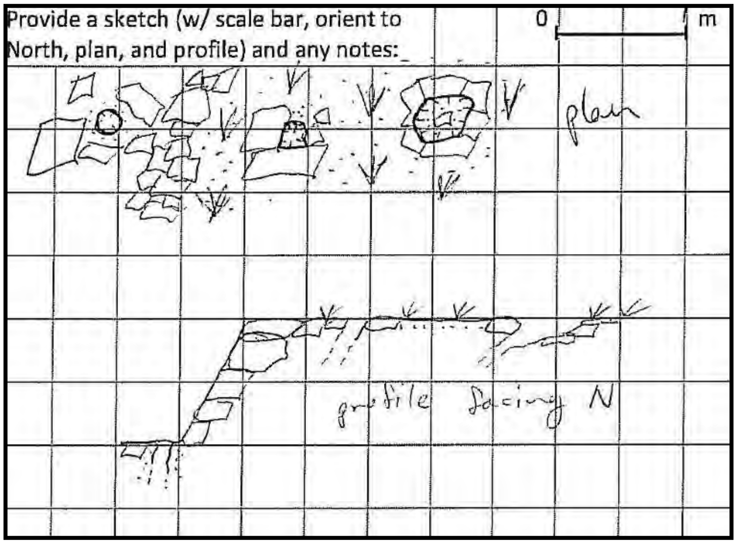


Figure 40. 281-053.

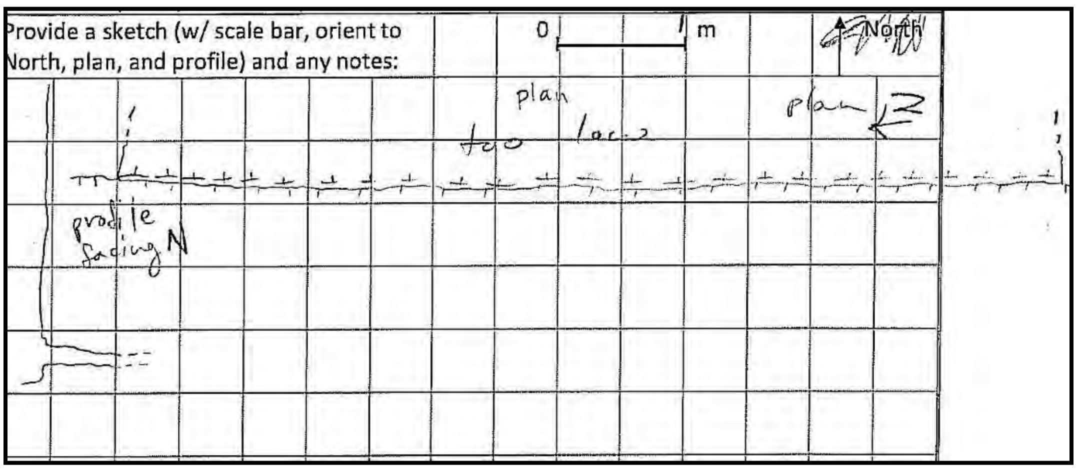


Figure 41. 281-054.

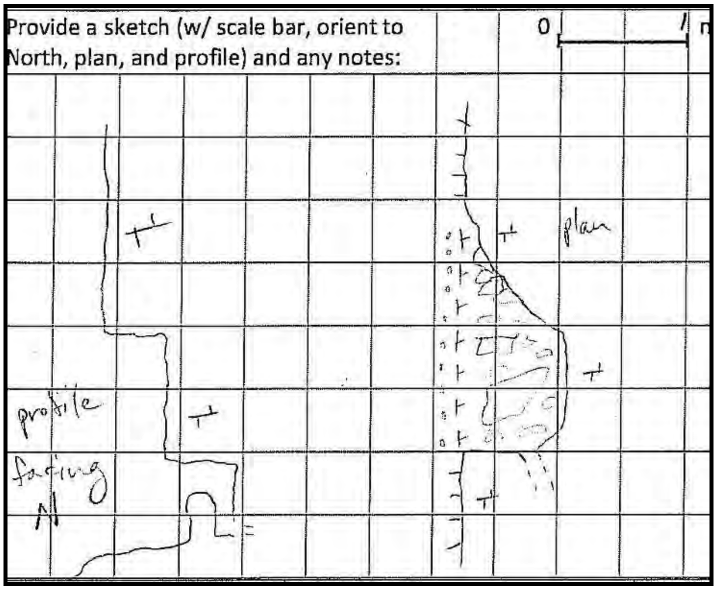


Figure 42. 281-055.

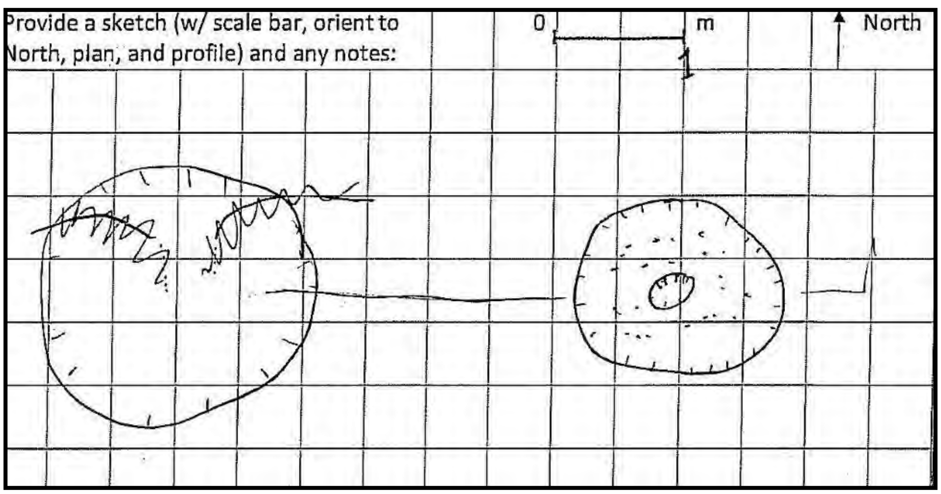


Figure 43. 281-056.

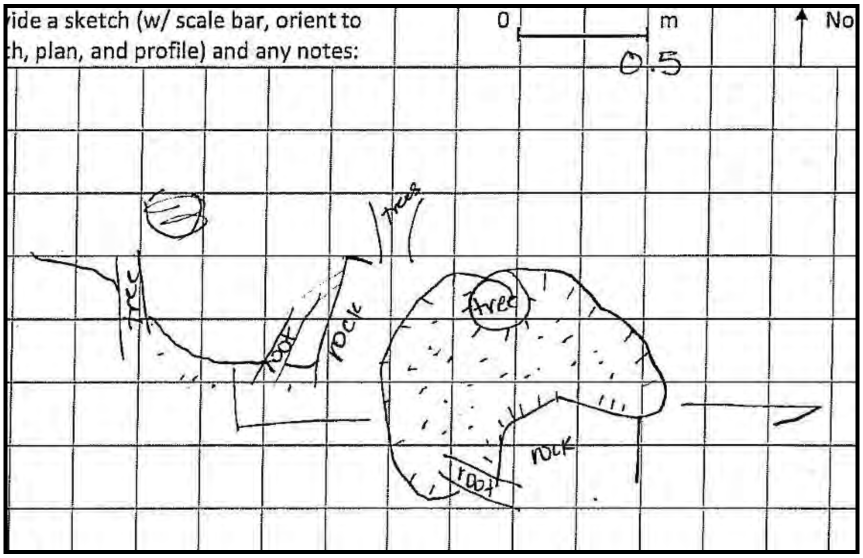


Figure 44. 281-057.

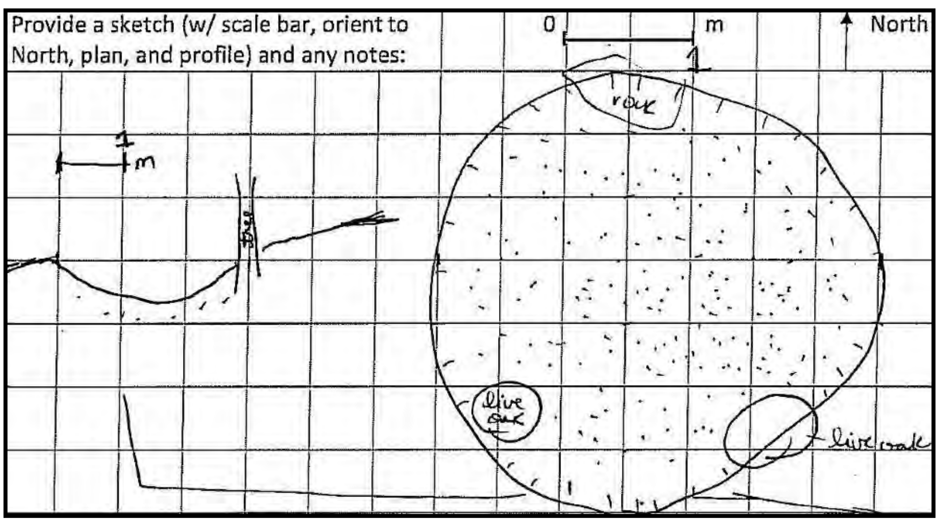


Figure 45. 281-058.

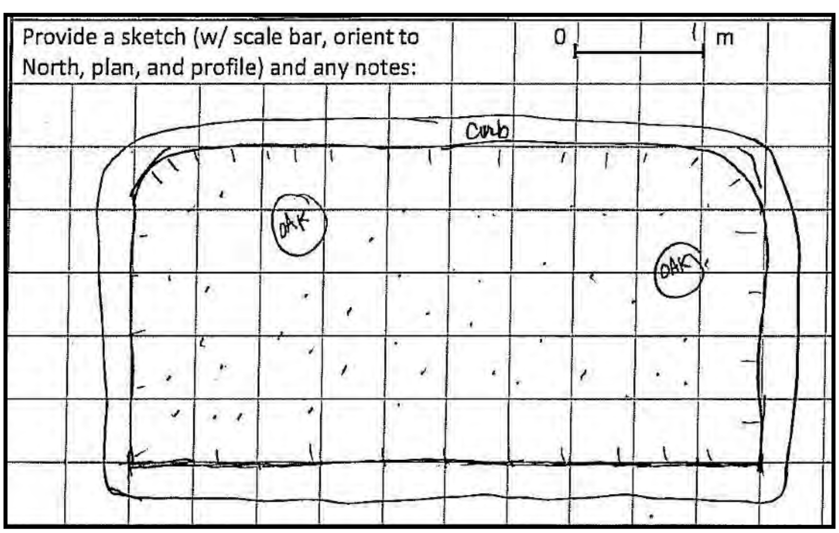


Figure 46. 281-059.

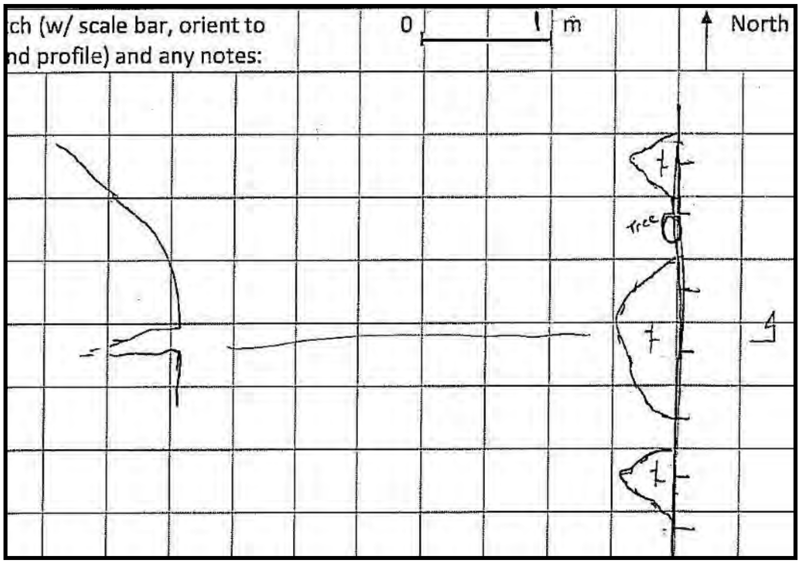


Figure 47. 281-060.

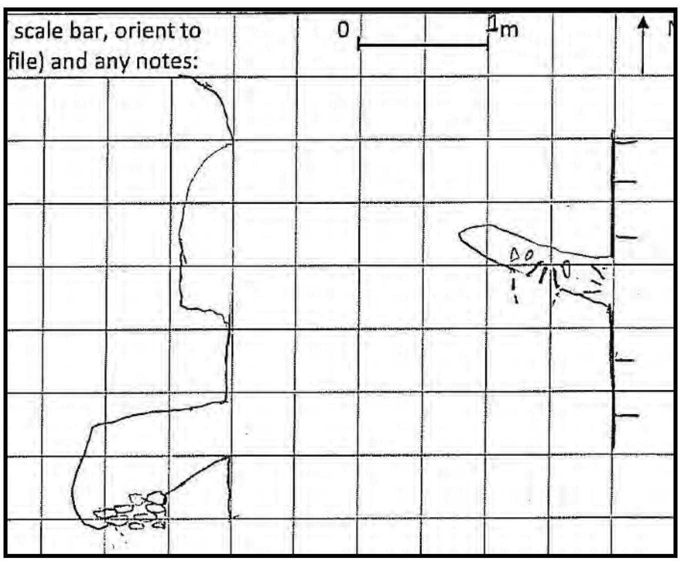


Figure 48. 281-061.

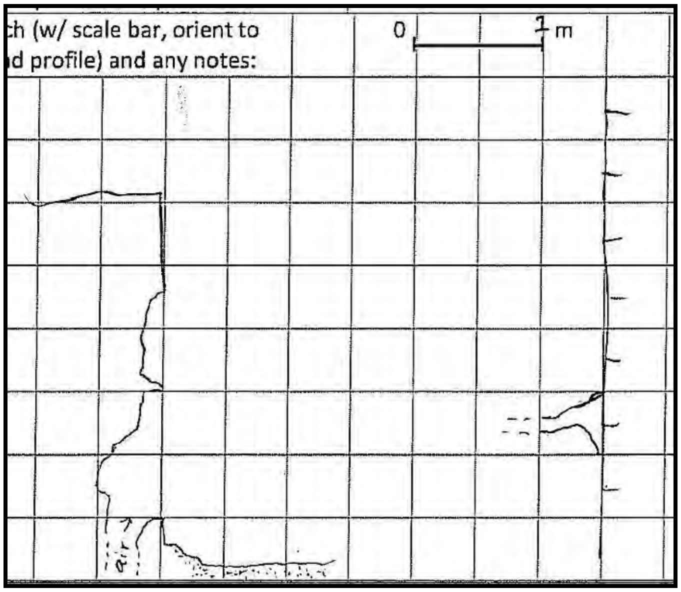


Figure 49. 281-065.

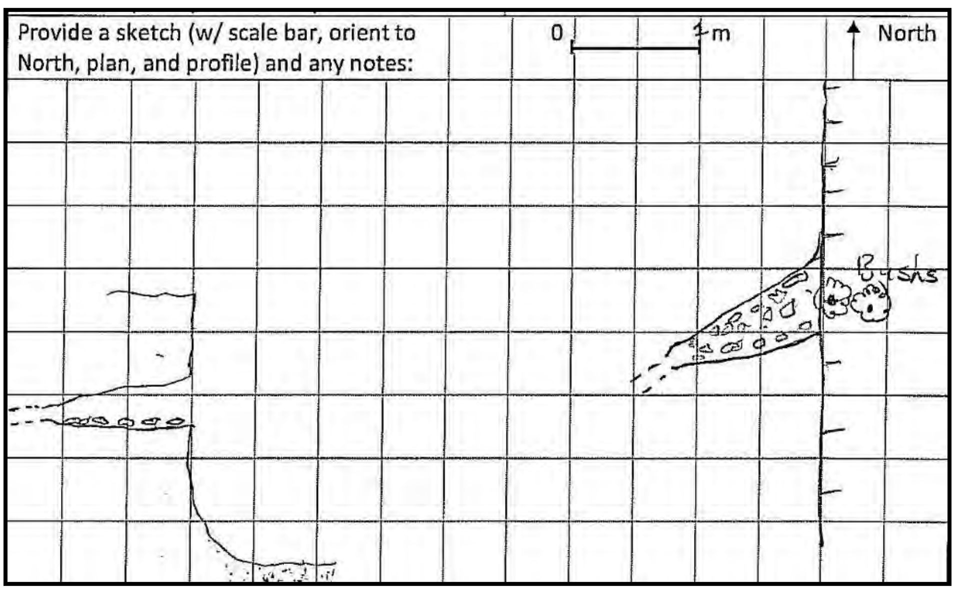


Figure 50. 281-066.

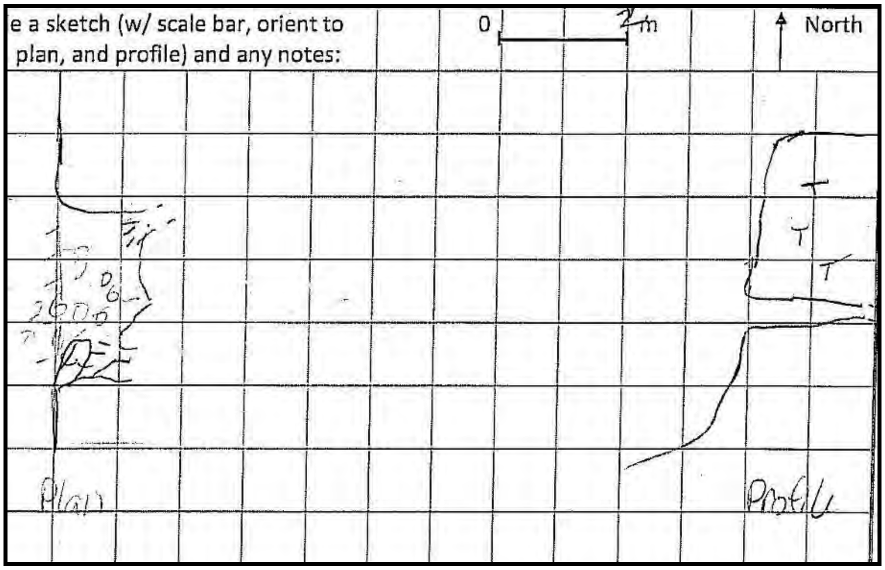


Figure 51. 281-069.

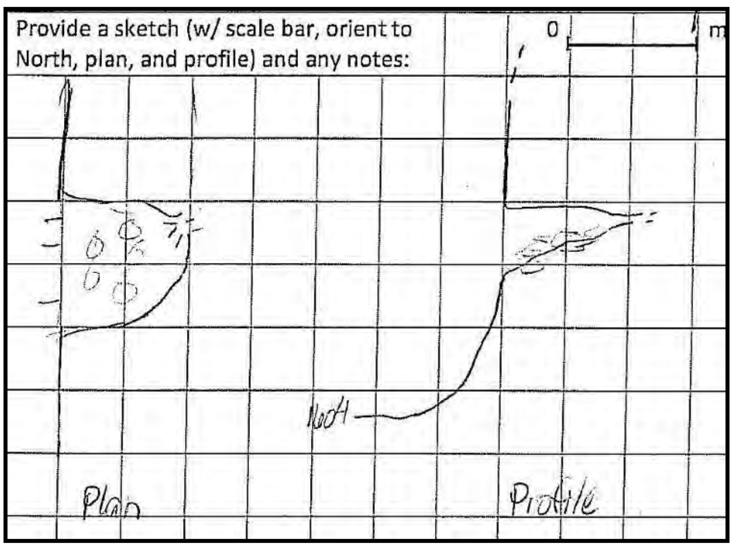


Figure 52. 281-074.

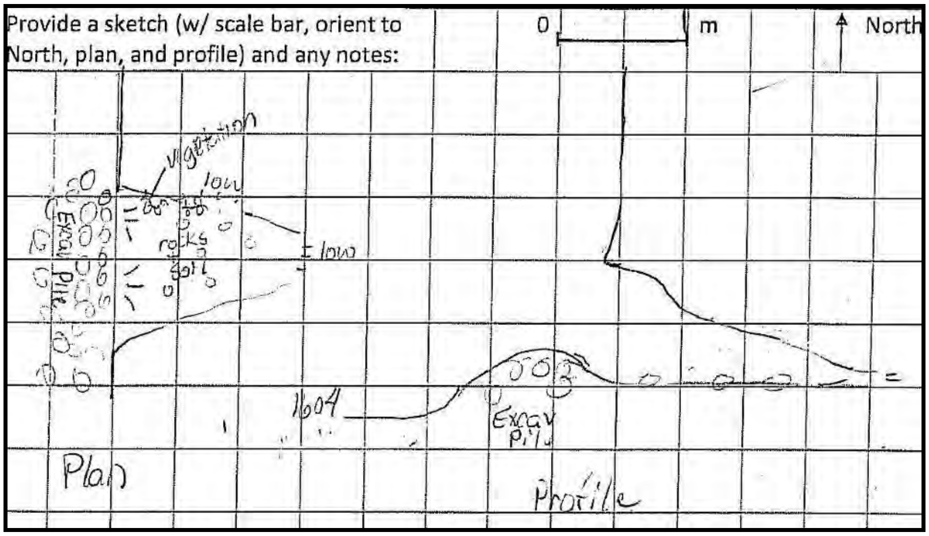


Figure 53. 281-075.

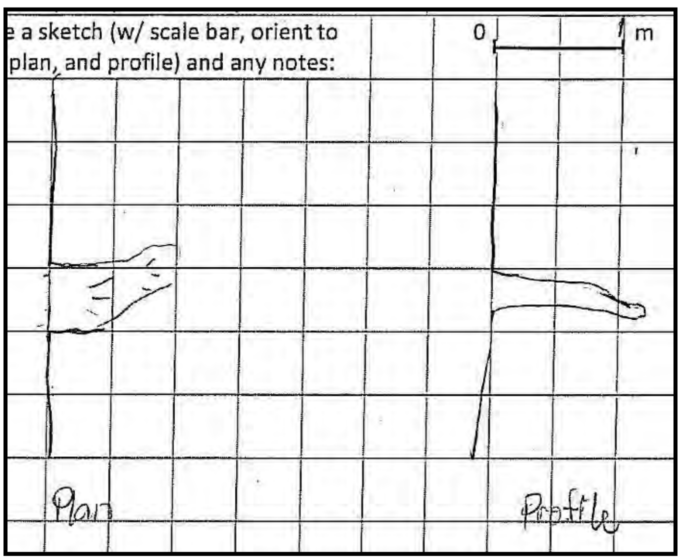


Figure 54. 281-076.

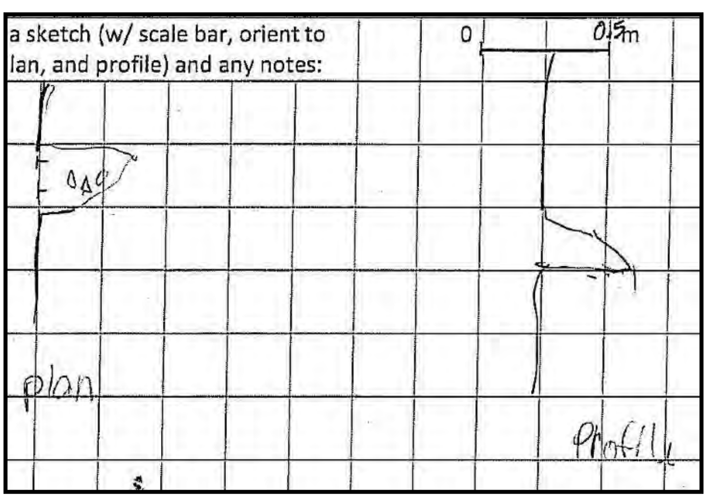


Figure 55. 281-077.

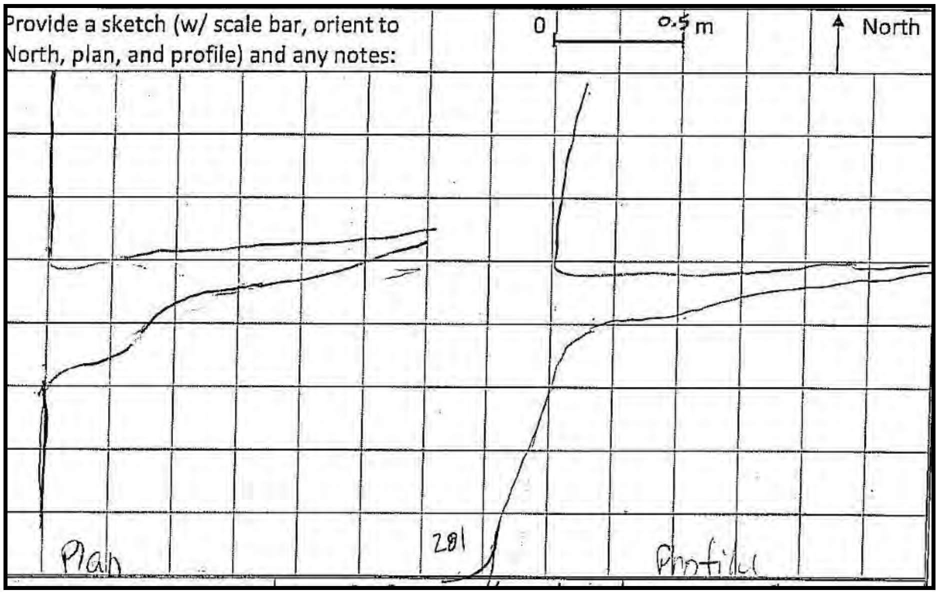


Figure 56. 281-078.

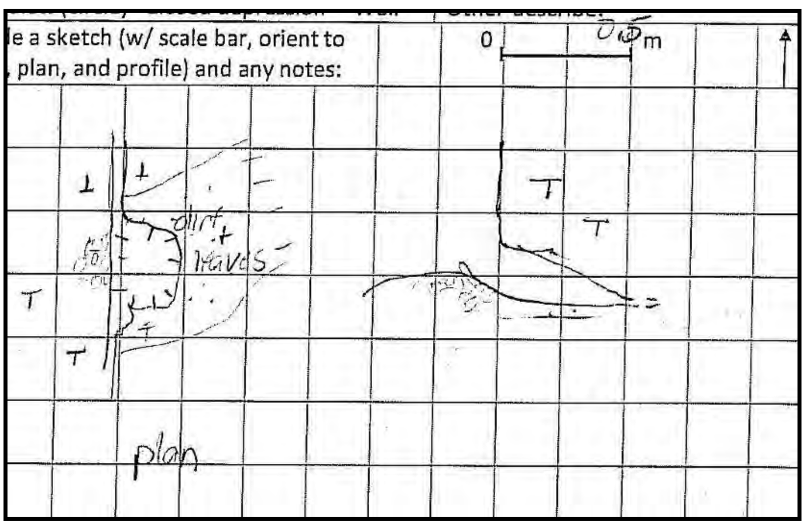


Figure 57. 281-079.

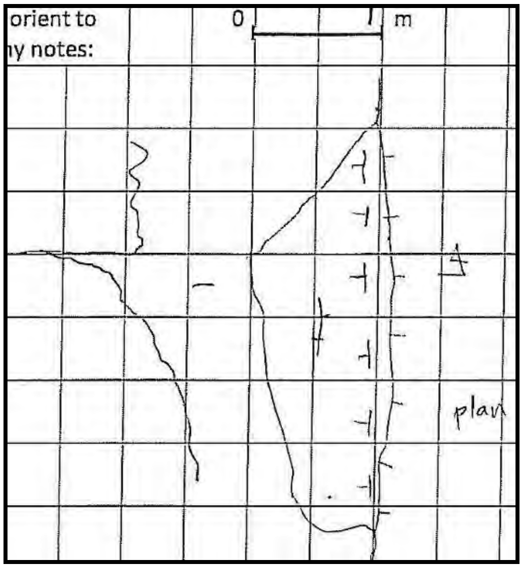


Figure 58. 281-082.

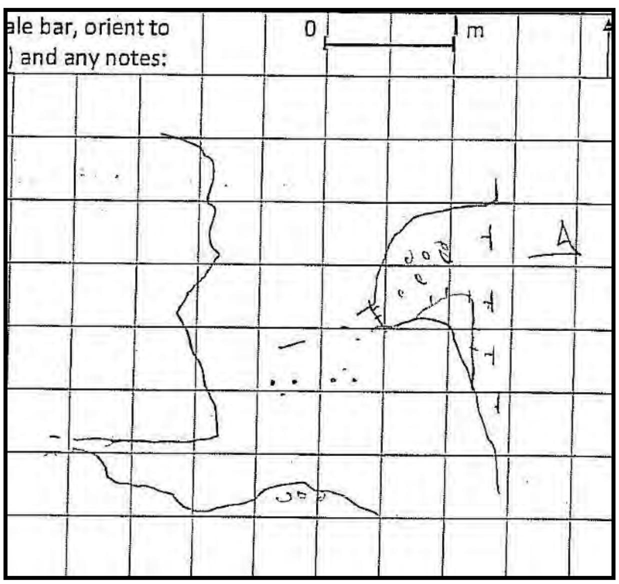


Figure 59. 281-086?

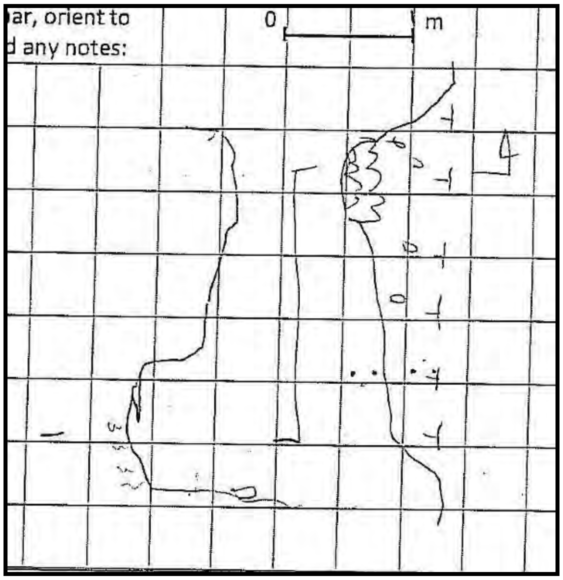


Figure 60. 281-087.

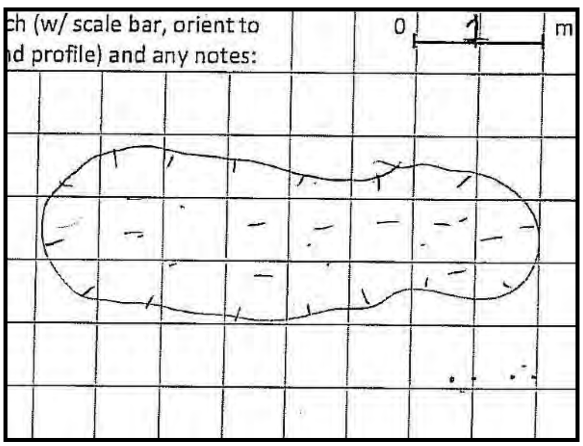


Figure 61. 281-094.

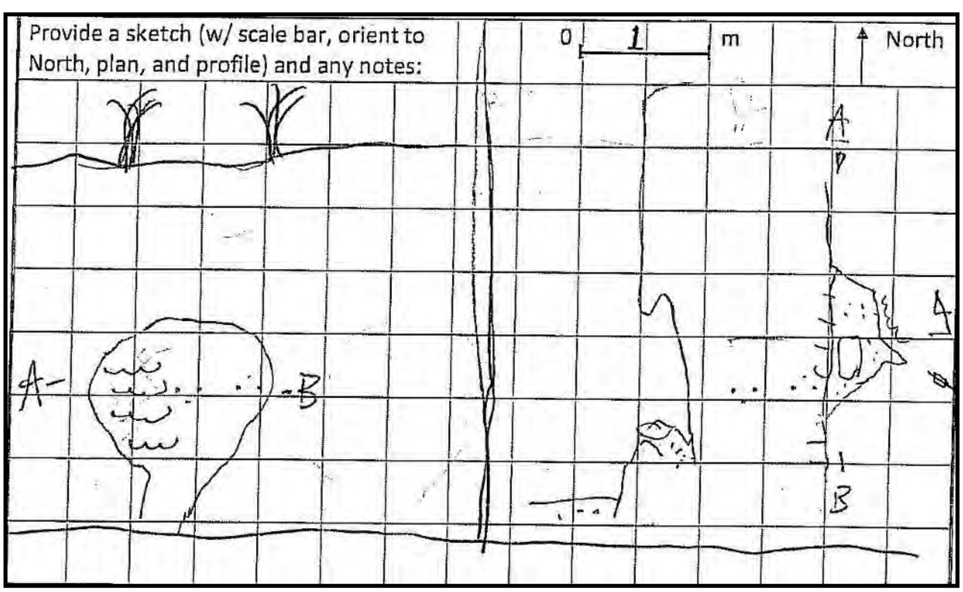


Figure 62. 281-095.

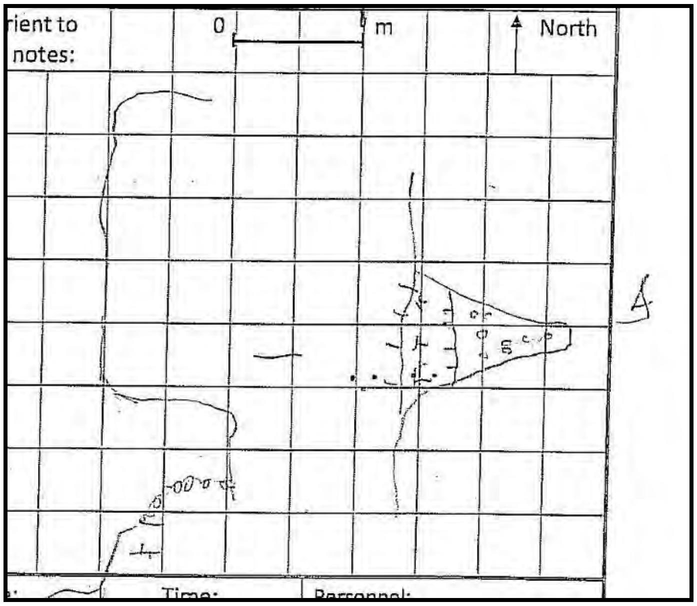


Figure 63. 281-096.

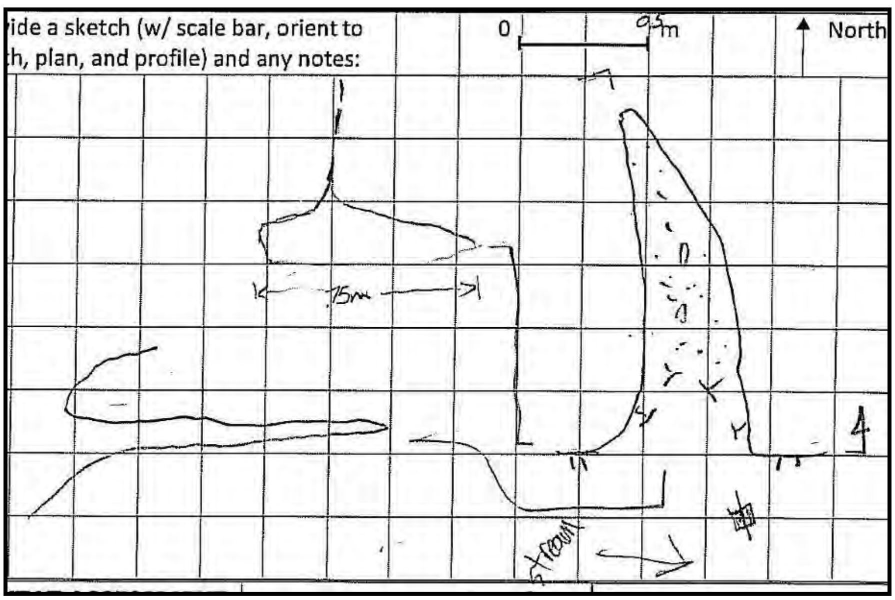


Figure 64. 281-098.

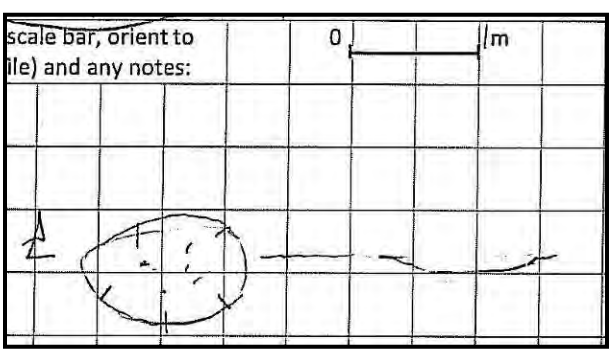


Figure 65. 281-099.

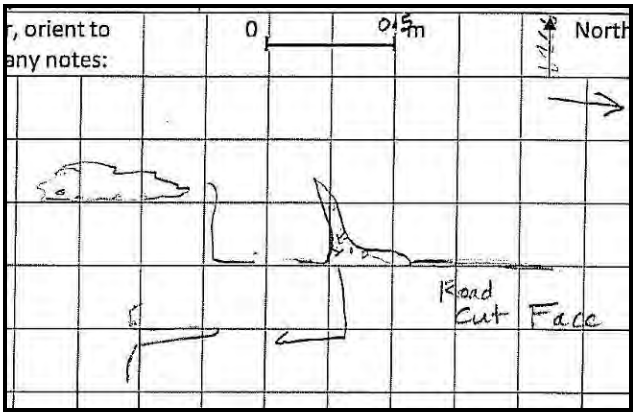


Figure 66. 281-102.

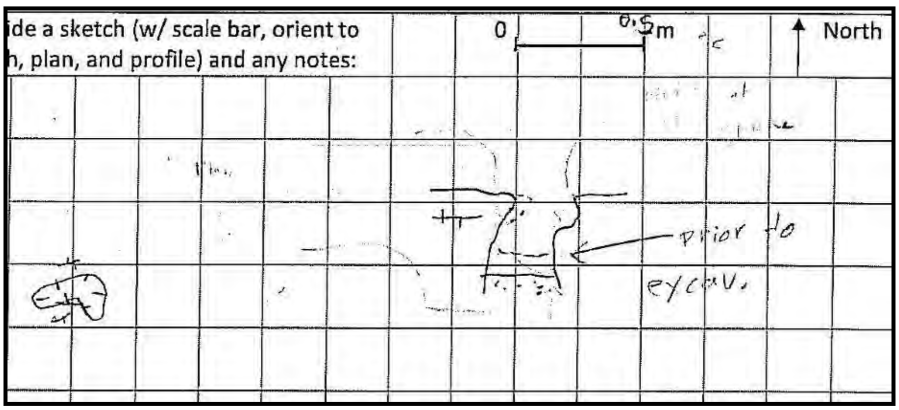


Figure 67. Field sketch of feature 281-103

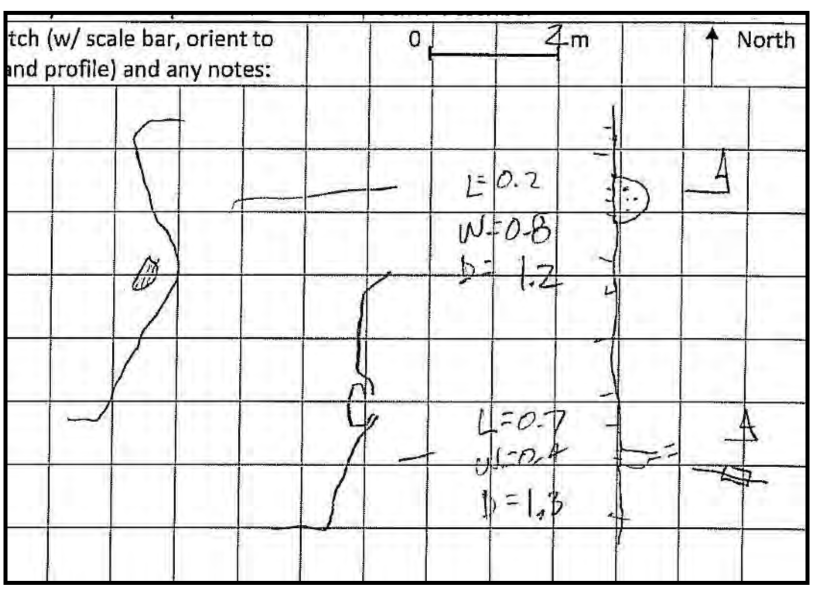


Figure 68. Field sketch of feature 281-104

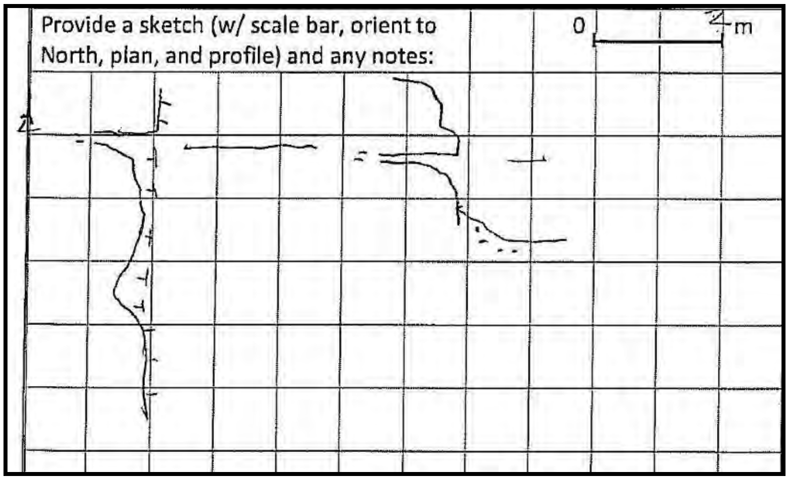


Figure 69. Field sketch of feature 281-105

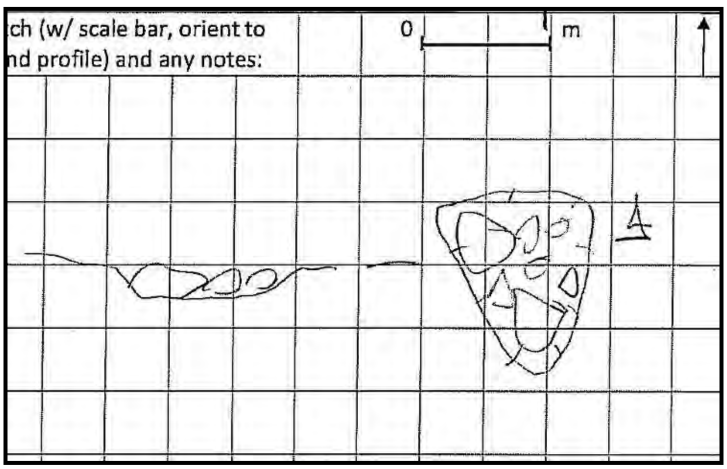


Figure 70. Field sketch of feature 281-107

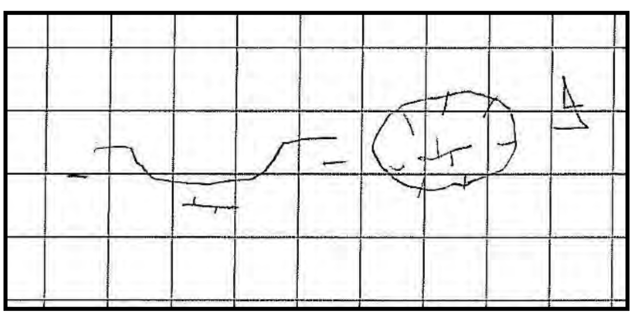


Figure 71. Field sketch of feature 281-108; 1 square = 1 meter

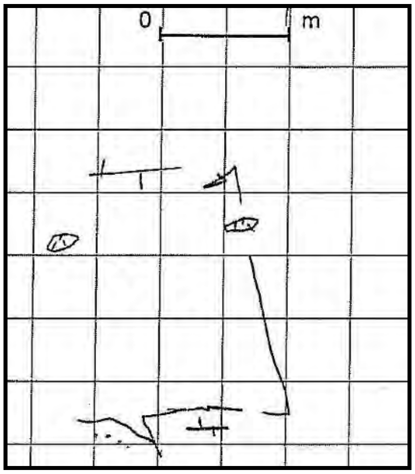


Figure 72. Field sketch of feature 281-109

DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX D

FEATURE COORDINATES

Feature Coordinates

Name	Latitude	Longitude	Estimated Position Error
281-001	29.71045	-98.44968333	6 m
281-002	29.70746667	-98.44963333	5 m
281-003	29.70845	-98.44908333	7 m
281-004	29.70145	-98.45075	5 m
281-005	29.70196667	-98.45066667	7 m
281-006	29.70398333	-98.45096667	4 m
281-007	29.70341667	-98.45105	3 m
281-008	29.69786667	-98.45185	5 m
281-009	29.70156667	-98.45145	4 m
281-010	29.7045	-98.45208333	6 m
281-011	29.69631667	-98.4534	5 m
281-012	29.7055	-98.45141667	4 m
281-013	29.69255	-98.45306667	6 m
281-014	29.69298333	-98.45316667	6 m
281-015	29.69201667	-98.45371667	5 m
281-016	29.66665	-98.44973333	6 m
281-017	29.67173333	-98.45065	10 m
281-018	29.67545	-98.45178333	6 m
281-019	29.6873	-98.45213333	8 m
281-020	29.6869	-98.4516	5 m
281-021	29.68698333	-98.45155	5 m
281-022	29.68611667	-98.4525	7 m
281-023	29.68416667	-98.45248333	8 m
281-024	29.68436667	-98.45171667	5 m
281-025	29.68431667	-98.45081667	5 m
281-026	29.66536667	-98.44843333	6 m
281-027	29.70996667	-98.44735	8 m
281-028	29.70843693	-98.447974	
281-029	29.68908	-98.45418	5 m
281-030	29.68907	-98.45407	6 m
281-031	29.6891333	-98.453983333	4 m
281-032	29.68911667	-98.453583333	6 m
281-033	29.68301667	-98.4528	6 m
281-034	29.68353333	-98.45195	5 m
281-035	29.68051667	-98.45488333	4 m
281-036	29.68033333	-98.45513333	5 m
281-037	29.66333	-98.4488	4 m

Name	Latitude	Longitude	Estimated Position Error
281-038	29.65918333	-98.45175	5 m
281-039	29.6578	-98.4514667	4 m
281-040	29.65716	-98.45121	5 m
281-041	29.65735	-98.4518	6 m
281-042	29.658	-98.45153333	7 m
281-043	29.64951667	-98.45155	6 m
281-044	29.65011667	-98.45111667	5 m
281-045	29.65198333	-98.45023333	5 m
281-046	29.65645	-98.451	6 m
281-047	29.655	-98.4508	4 m
281-048	29.6475	-98.4526	5 m
281-049	29.69061667	-98.45445	7 m
281-050	29.68796667	-98.451667	5 m
281-051	29.66533333	-98.44865	4 m
281-052	29.66087	-98.45171	7 m
281-053	29.66089	-98.45192	6 m
281-054	29.63959	-98.45328	5 m
281-055	29.63985	-98.45314	7 m
281-056	29.6186	-98.4655	10 m
281-057	29.6201	-98.46435	4 m
281-058	29.62078333	-98.46328333	4 m
281-059	29.6344	-98.45593333	6 m
281-060	29.62458333	-98.46348333	7 m
281-061	29.62918333	-98.46096667	8 m
281-062	29.6294	-98.46088333	9 m
281-063	29.62946667	-98.4608	12 m
281-064	29.62988333	-98.4606	8 m
281-065	29.63536667	-98.45763333	6 m
281-066	29.62936667	-98.46093333	7 m
281-067	29.66098333	-98.45115	4 m
281-068	29.66096667	-98.45088333	4 m
281-069	29.66036667	-98.44993333	5 m
281-070	29.6602976	-98.4499316	5 m
281-071	29.6602344	-98.4499216	5 m
281-072	29.6601261	-98.4499222	5 m
281-073	29.660063	-98.4499329	6 m
281-074	29.65951667	-98.44995	5 m
281-075	29.6588	-98.44995	5 m
281-076	29.64158333	-98.45371667	4 m

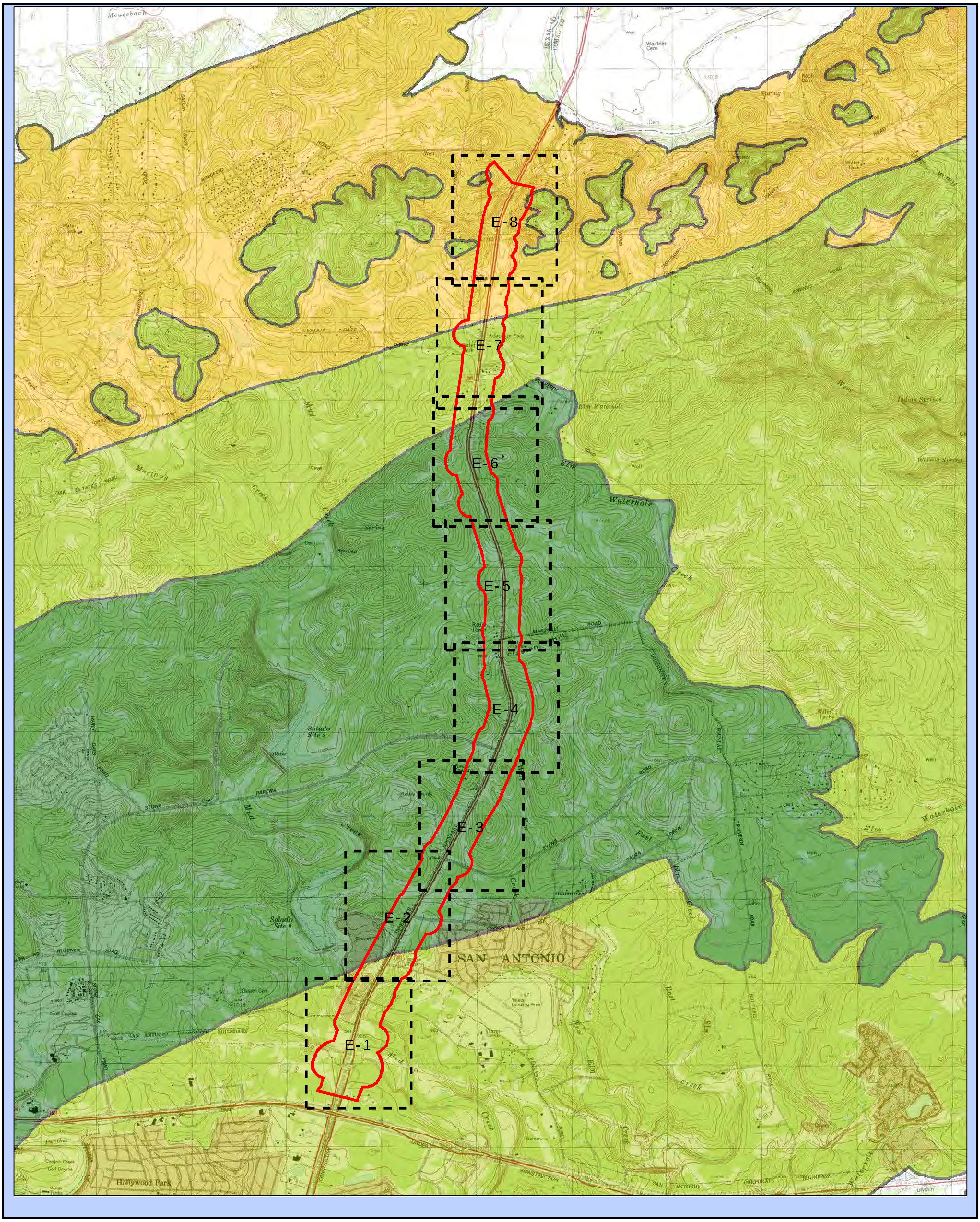
Name	Latitude	Longitude	Estimated Position Error
281-077	29.64251667	-98.45323333	4 m
281-078	29.6432	-98.45283333	6 m
281-079	29.67901667	-98.45146667	5 m
281-080	29.6136	-98.46776667	5 m
281-081	29.6345	-98.45811667	3 m
281-082	29.64395	-98.45303333	3 m
281-083	29.6598487	-98.4504817	
281-084	29.6598125	-98.4504612	6 m
281-085	29.6598125	-98.4504612	6 m
281-086	29.65958	-98.45047	3 m
281-087	29.6533333	-98.4504667	
281-088	29.6593859	-98.4498746	
281-089	29.6593047	-98.4498853	
281-090	29.63733	-98.4566	6 m
281-091	29.6592054	-98.4498756	
281-092	29.70371	-98.45103	3 m
281-093	29.70379	-98.45103	4 m
281-094	29.64755	-98.45248	2 m
281-095	29.68201	-98.45353	3 m
281-096	29.68207	-98.45353	3 m
281-097	29.64975311	-98.45132253	
281-098	29.70558	-98.4511	5 m
281-099	29.700272	-98.450985	5 m
281-100	29.69547	-98.45128	4 m
281-101	29.69415	-98.45251	3 m
281-102	29.68692	-98.45341	4 m
281-103	29.65625	-98.45127	5 m
281-104	29.62009	-98.46519	3 m
281-105	29.6302	-98.46045	3 m
281-106	29.6355	-98.45687	4 m
281-107	29.63971	-98.45355	3 m
281-108	29.65444	-98.44859	3 m
281-109	29.64756	-98.45228	4 m
281-110	29.69489	-98.45223	
281-111	29.69353	-98.45235	
281-112	29.68496	-98.45342	
281-113	29.66890	-98.45033	
281-114	29.65028	-98.45027	
281-115	29.64439	-98.45247	

Name	Latitude	Longitude	Estimated Position Error
281-116	29.62667	-98.46180	

DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX E

FEATURE LOCATION AERIAL MAPS



Appendix E-Overview Map

Draft

Karst Zones data source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

N
W E
S

ZARA
ENVIRONMENTAL LLC

Study Area
plate extents

Karst Zones

- Zone 1 - Endangered species known to occur
- Zone 2 - Endangered species probably occur
- Zone 3 - Endangered species may occur
- Zone 4 - Endangered species probably do not occur

Kilometers
0 1 2 4

0 0.5 1 2 3
Miles

E-1, Aerial Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Aerial data source: Bexar County Appraisal District, 2009

- Surveyed Features
- Historic Features
- Historic Caves (TSS)
- Wells
- Study Area
- plate extents
- Faults

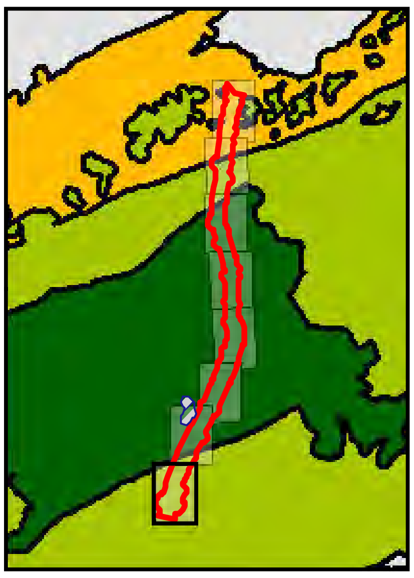
Karst Zones

- Zone 1 - Endangered species known to occur
- Zone 2 - Endangered species likely to occur
- Zone 3 - Endangered species probably do not occur
- Zone 4 - Area which requires further research
- Critical habitiat Unit

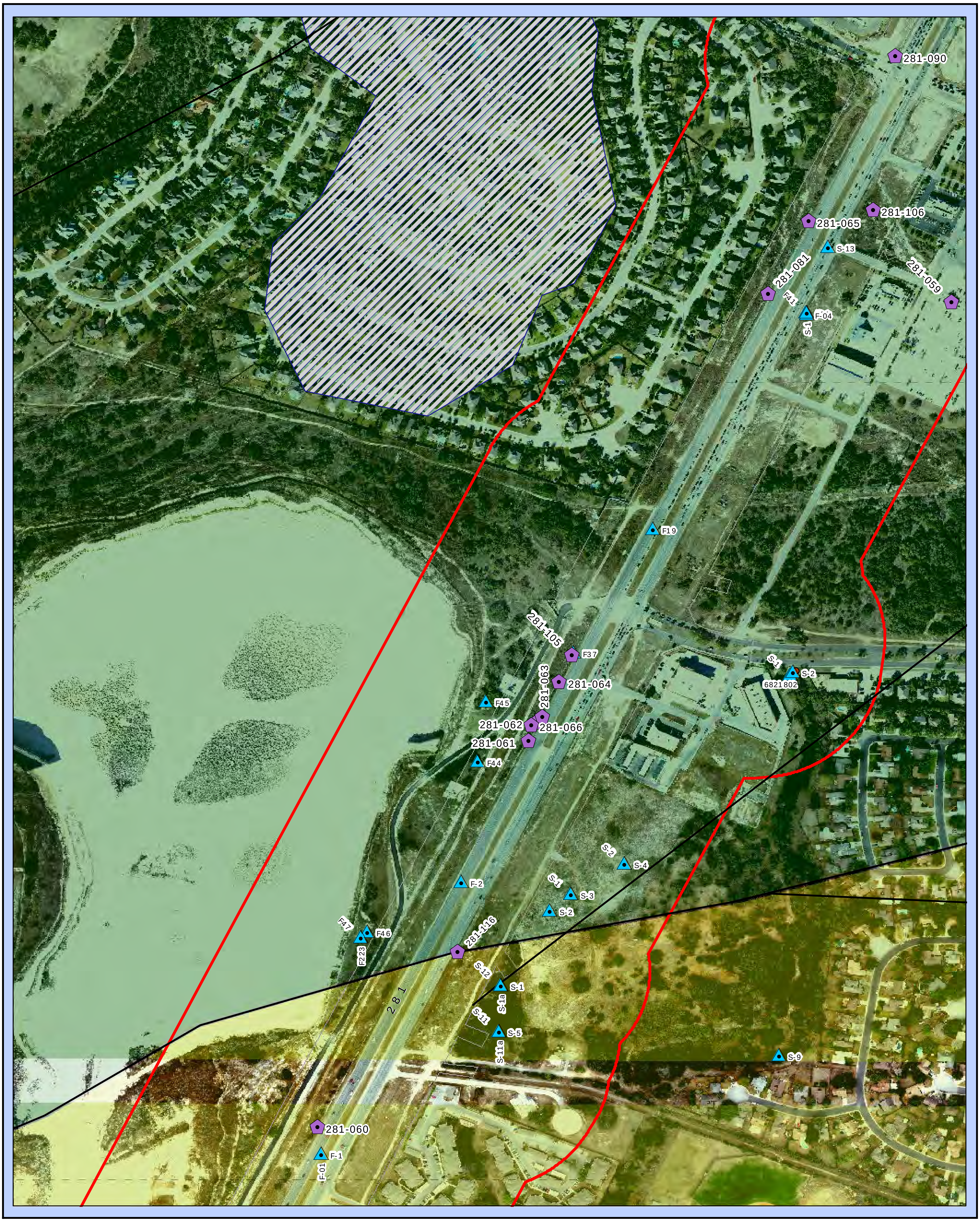
N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet



ZARA
ENVIRONMENTAL LLC



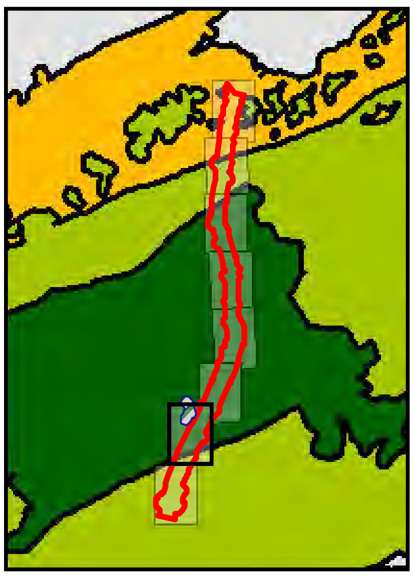
E-2, Aerial Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Aerial data source: Bexar County Appraisal District, 2009

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

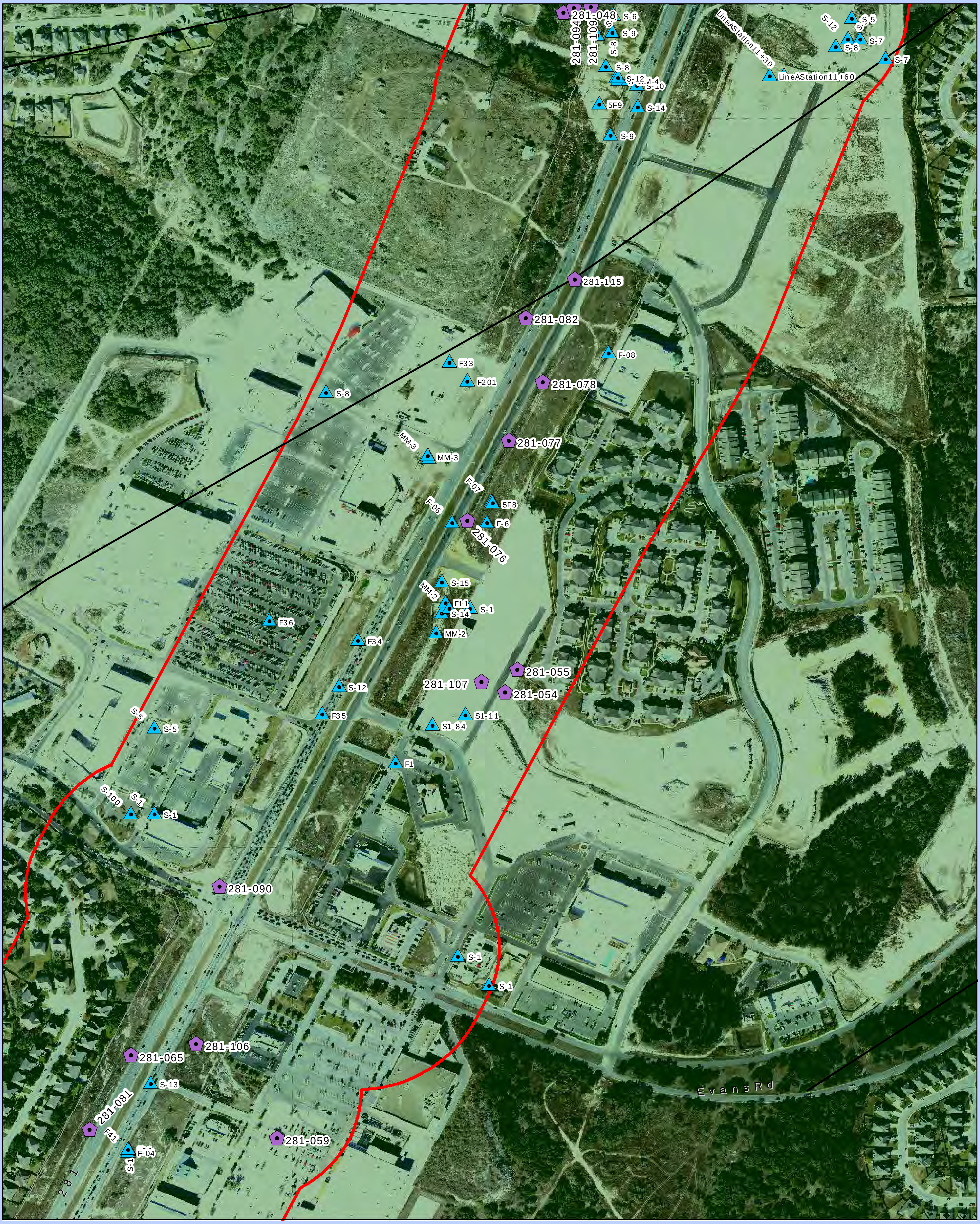


ZARA
ENVIRONMENTAL LLC

N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet



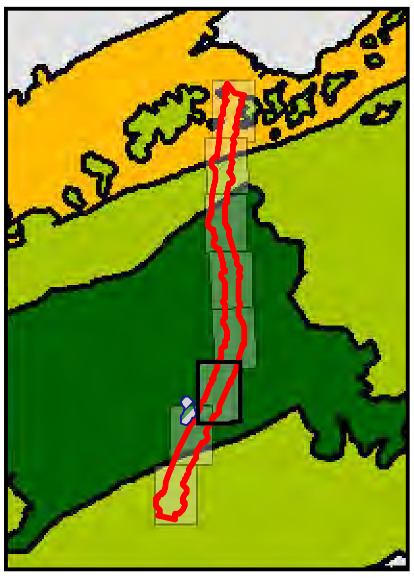
E-3, Aerial Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Aerial data source: Bexar County Appraisal District, 2009

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

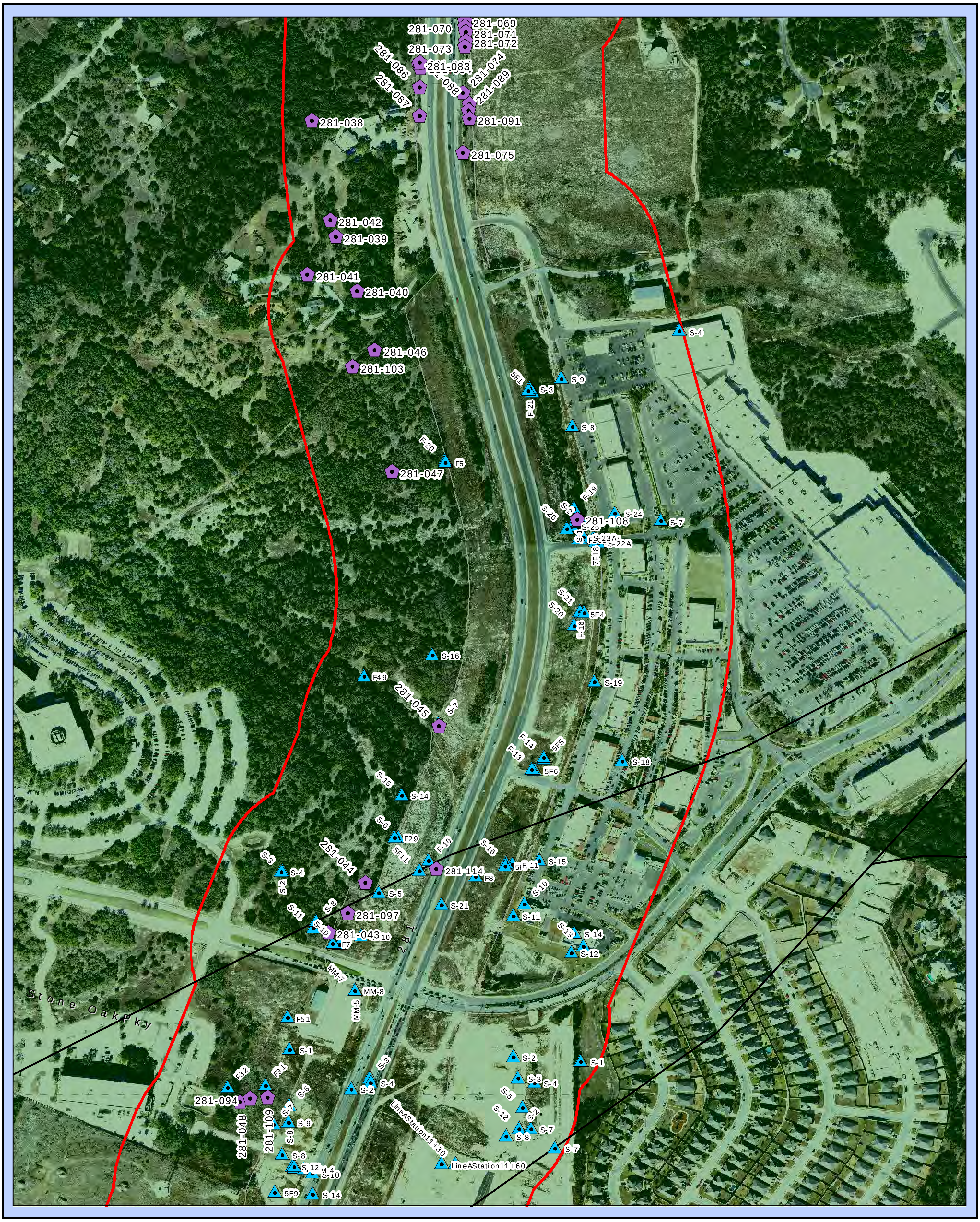
Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit



N
W E
S

Meters
0 125 250 500
0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC



E-4, Aerial Map

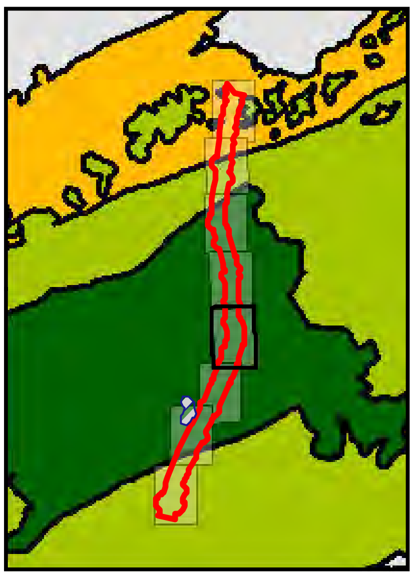
DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Aerial data source: Bexar County Appraisal District, 2009

- Surveyed Features
- Historic Features
- Historic Caves (TSS)
- Wells
- Study Area
- plate extents
- Faults

Karst Zones

- Zone 1 - Endangered species known to occur
- Zone 2 - Endangered species likely to occur
- Zone 3 - Endangered species probably do not occur
- Zone 4 - Area which requires further research
- Critical habitiat Unit



N
W E
S

Meters
0 125 250 500
0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC

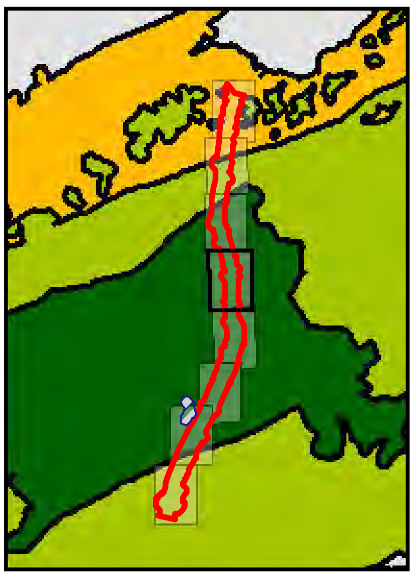
E-5, Aerial Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Aerial data source: Bexar County Appraisal District, 2009

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

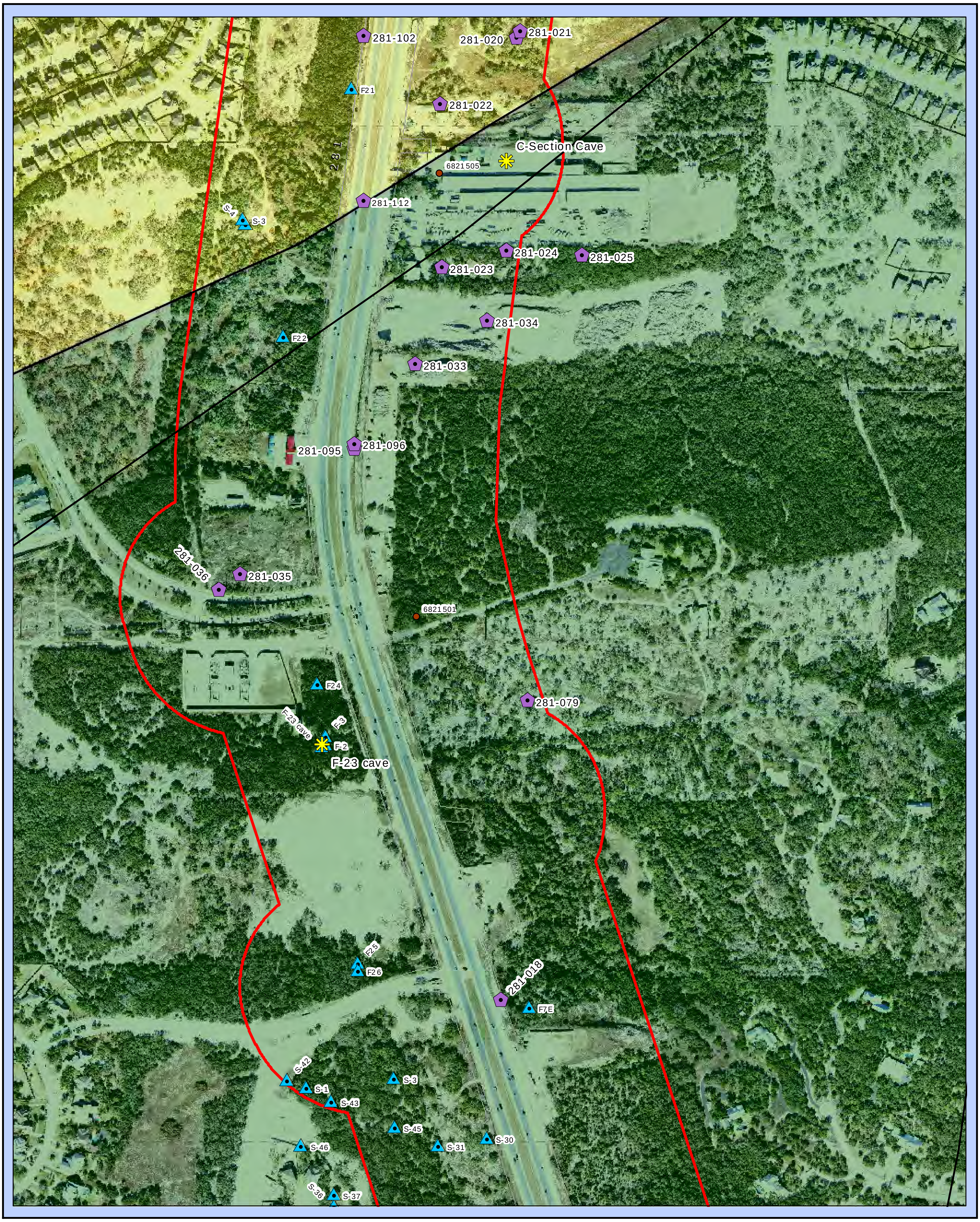
Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit



ZARA ENVIRONMENTAL LLC

N
W E
S

Meters
0 125 250 500
0 375 750 1,500
Feet



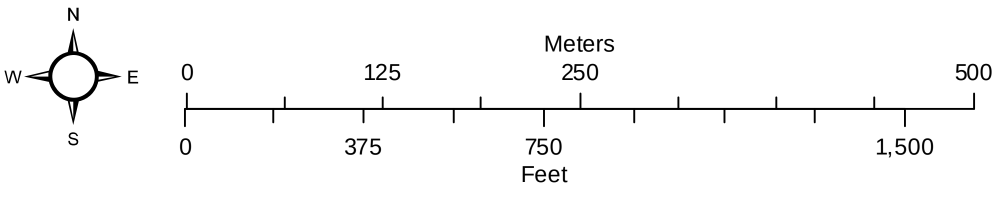
E-6, Aerial Map

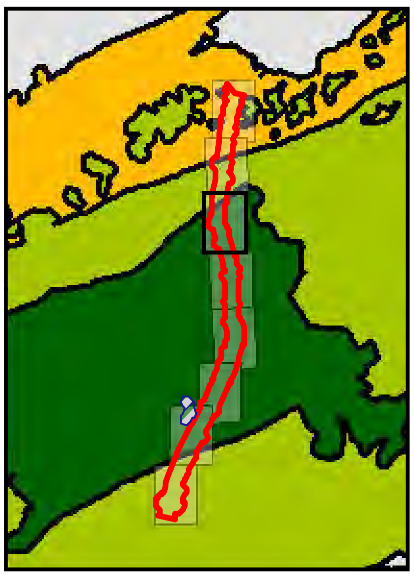
DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Aerial data source: Bexar County Appraisal District, 2009

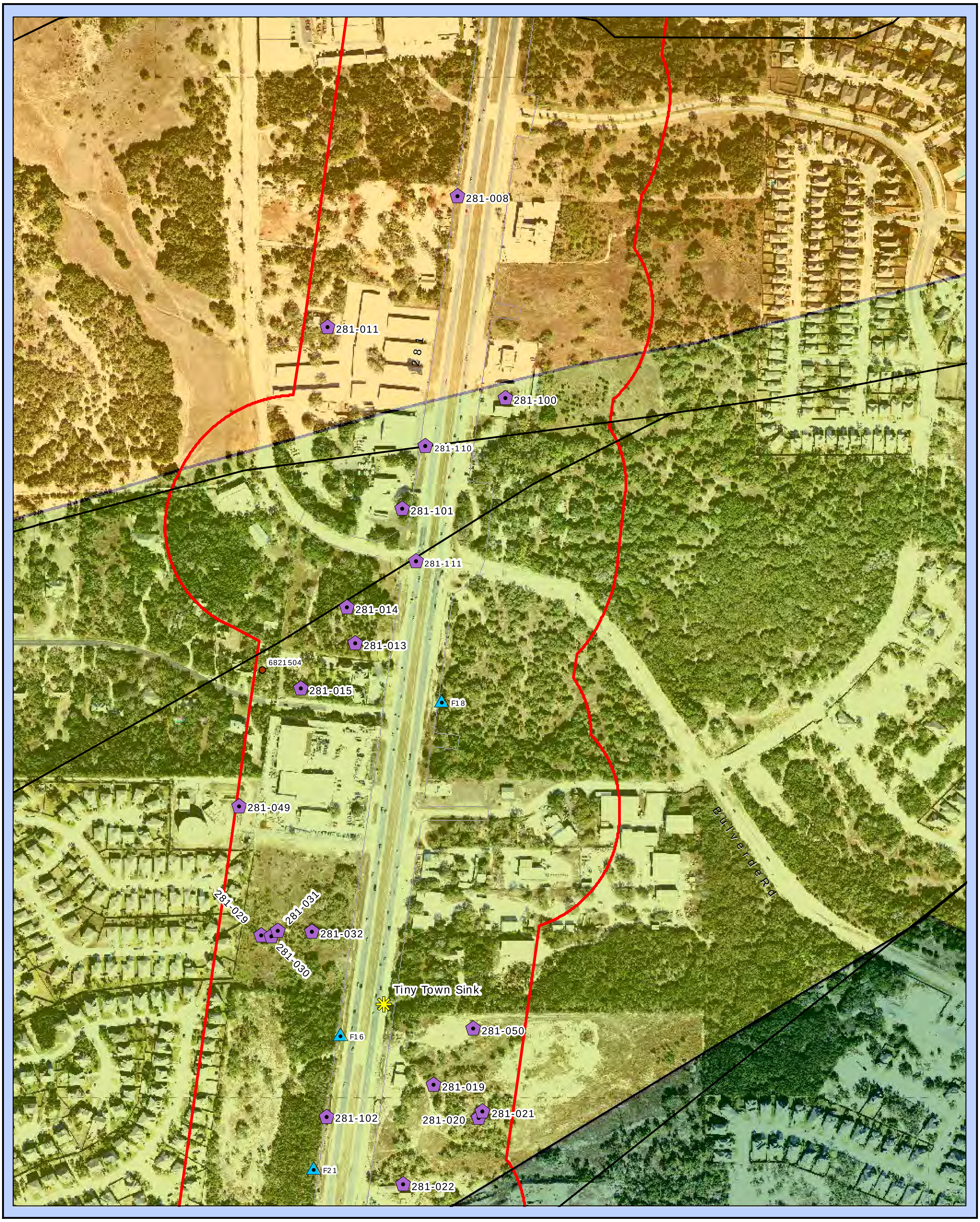
Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit





ZARA ENVIRONMENTAL LLC



E-7, Aerial Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Aerial data source: Bexar County Appraisal District, 2009

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

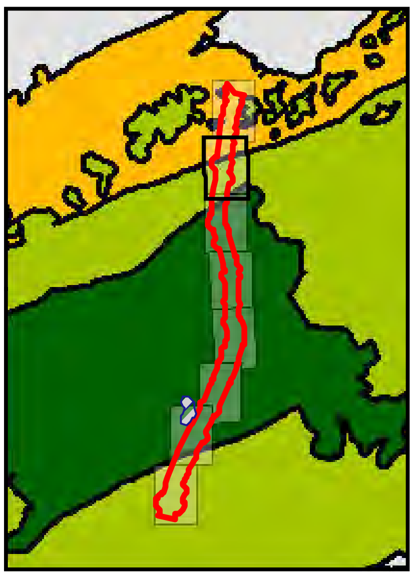
Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC



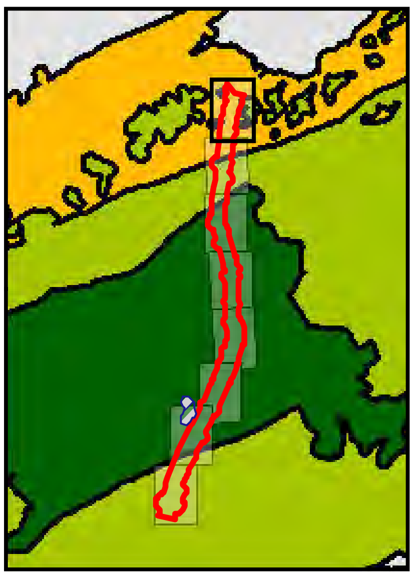
E-8, Aerial Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Aerial data source: Bexar County Appraisal District, 2009

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit



N
W E
S

Meters
0 125 250 500

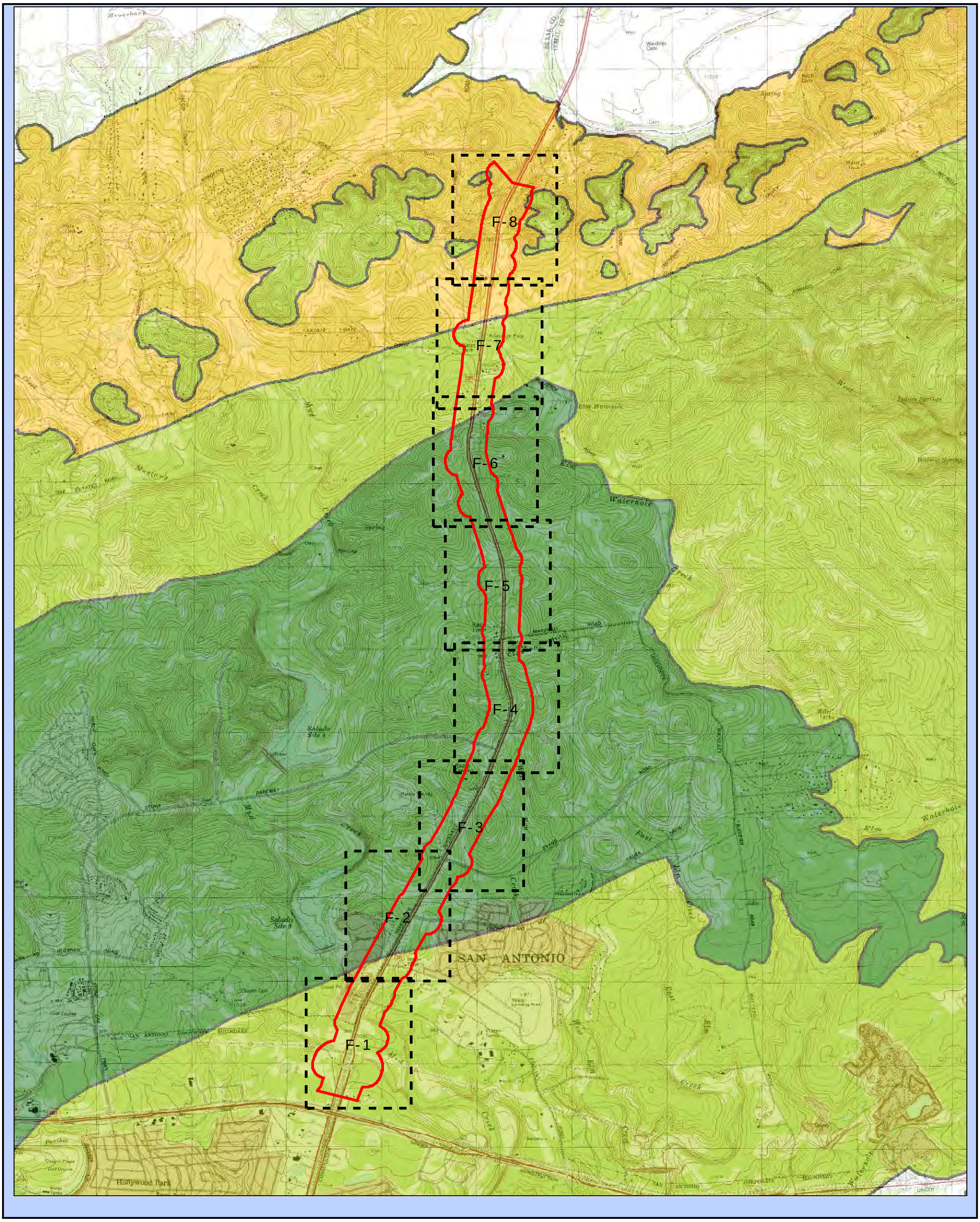
0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC

DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX F

FEATURE LOCATION TOPOGRAPHIC MAPS



Appendix F-Overview Map

Draft

Karst Zones data source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

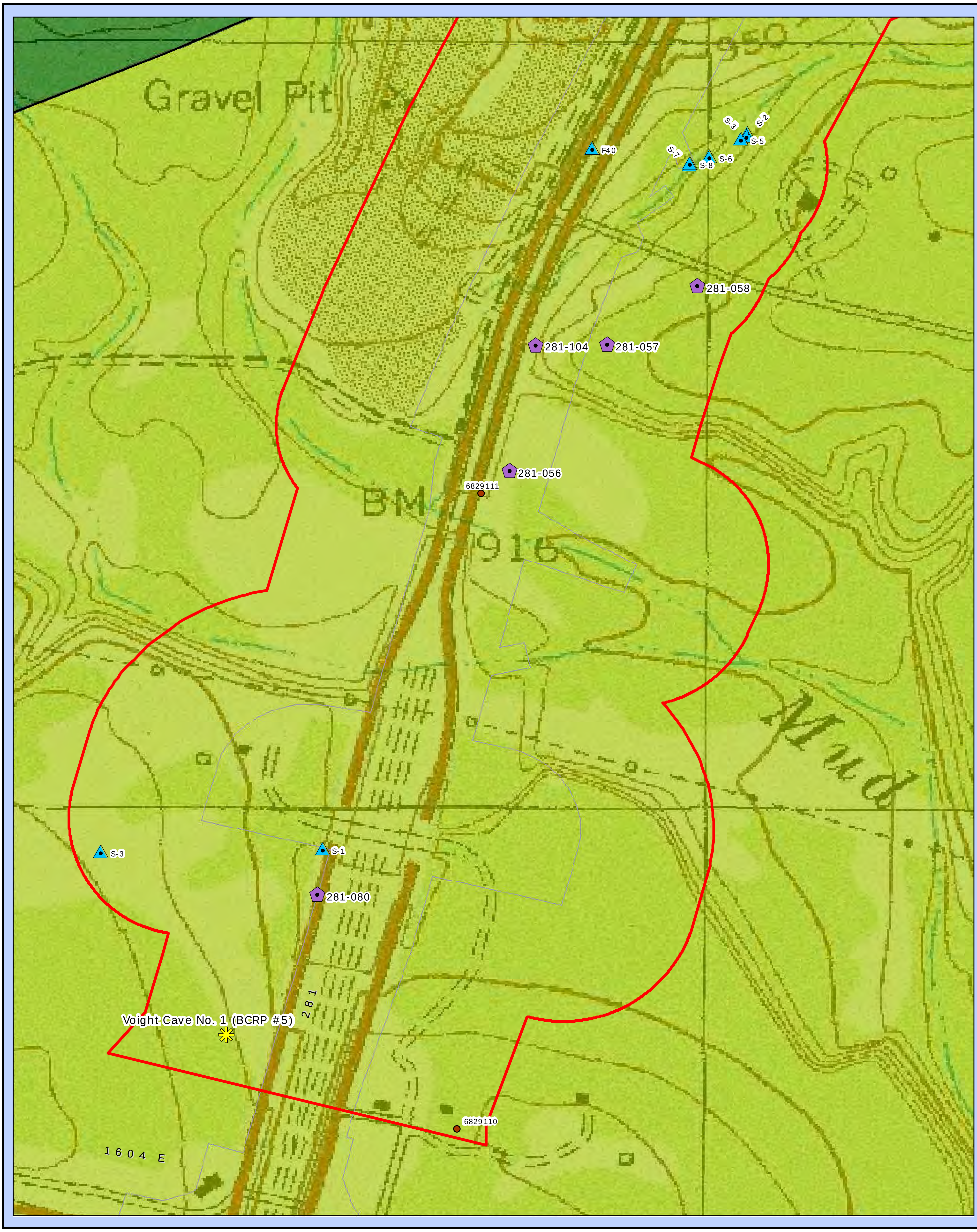
N
W E
S

ZARA ENVIRONMENTAL LLC

Study Area
plate extents

Karst Zones
- Zone 1 - Endangered species known to occur
- Zone 2 - Endangered species probably occur
- Zone 3 - Endangered species may occur
- Zone 4 - Endangered species probably do not occur

Kilometers
0 1 2 4
0 0.5 1 2 3
Miles



F-1, Topographic Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

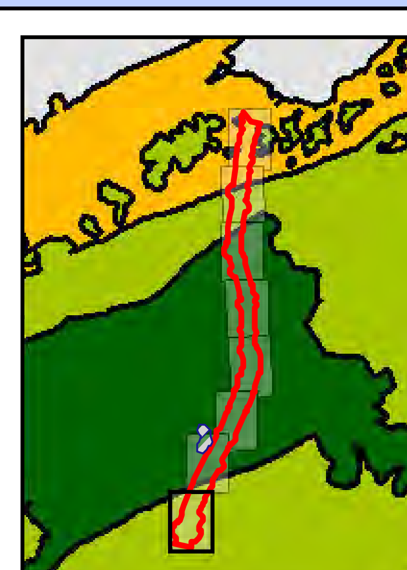
Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

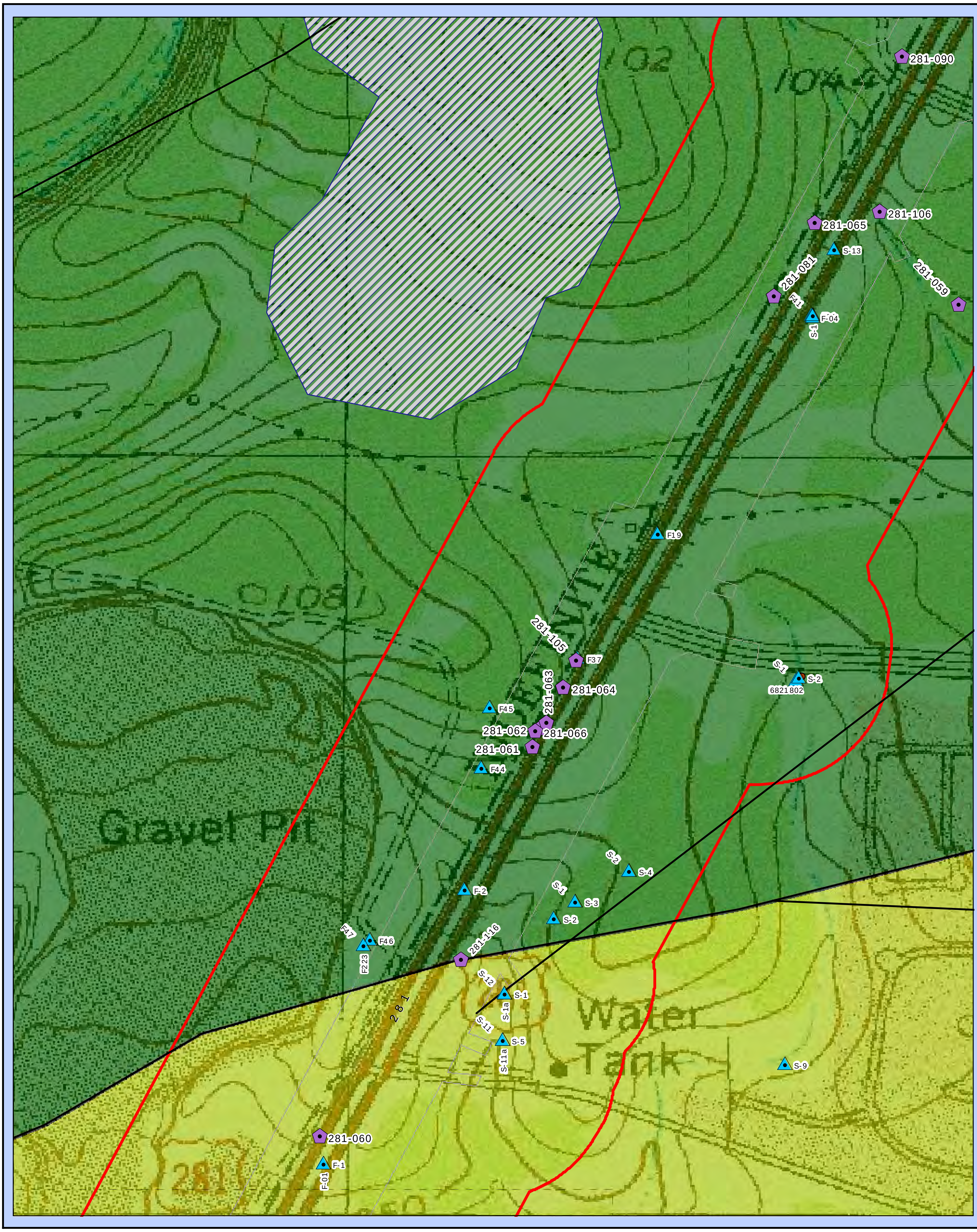
N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet



ZARA
ENVIRONMENTAL LLC



F-2, Topographic Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

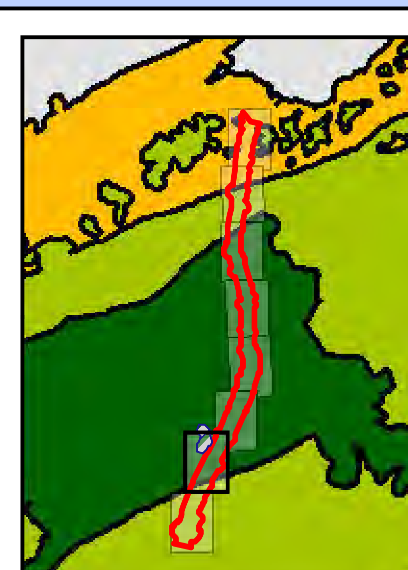
Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

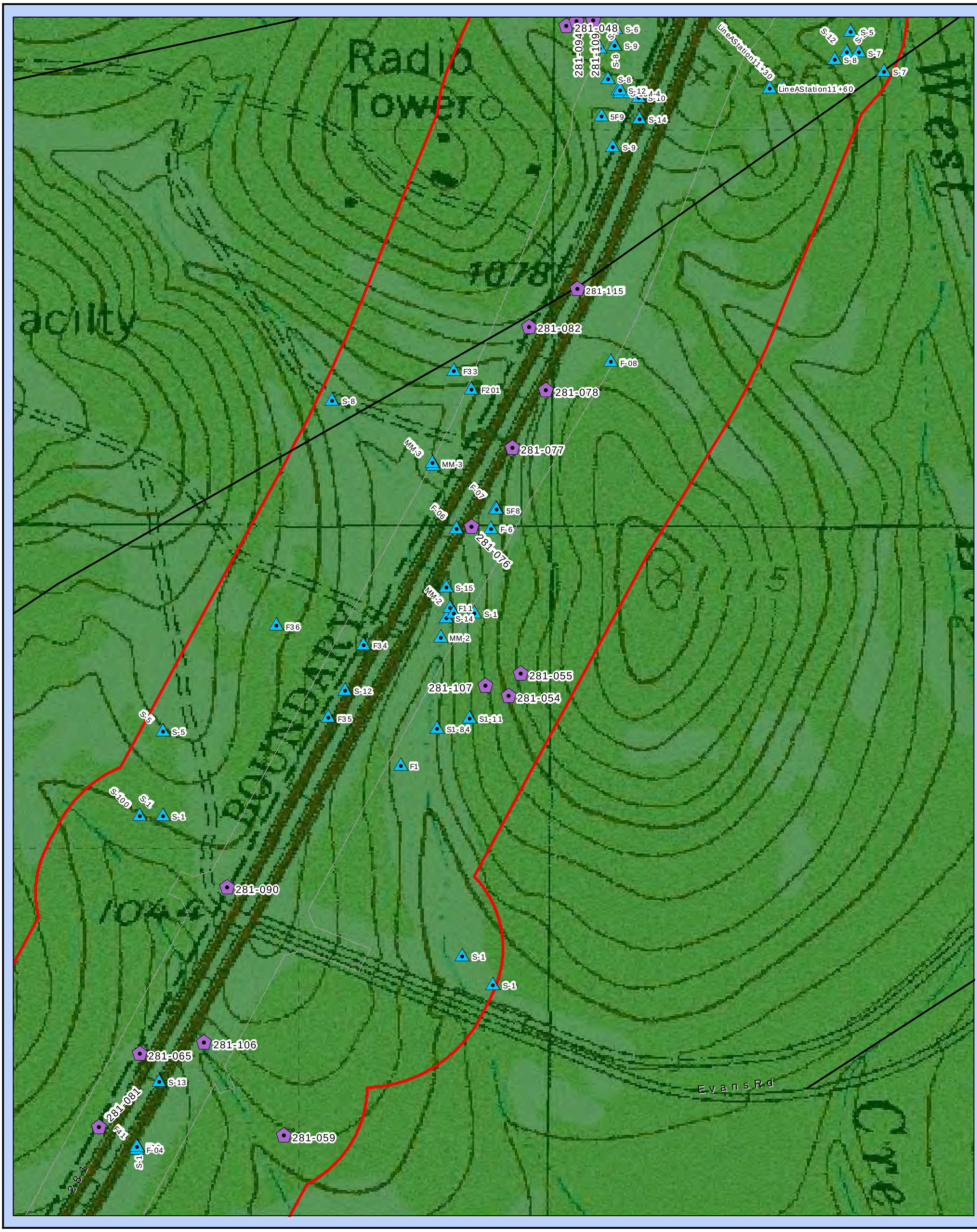
N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet



ZARA ENVIRONMENTAL LLC



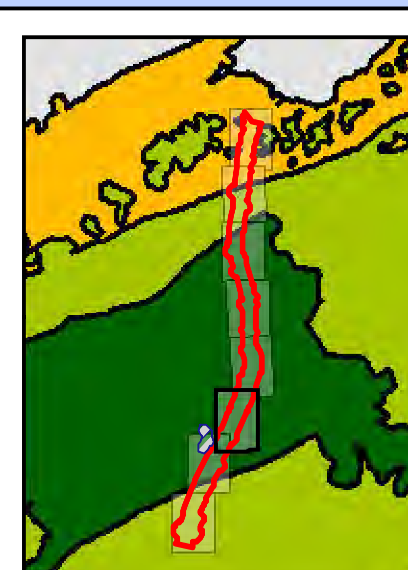
F-3, Topographic Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

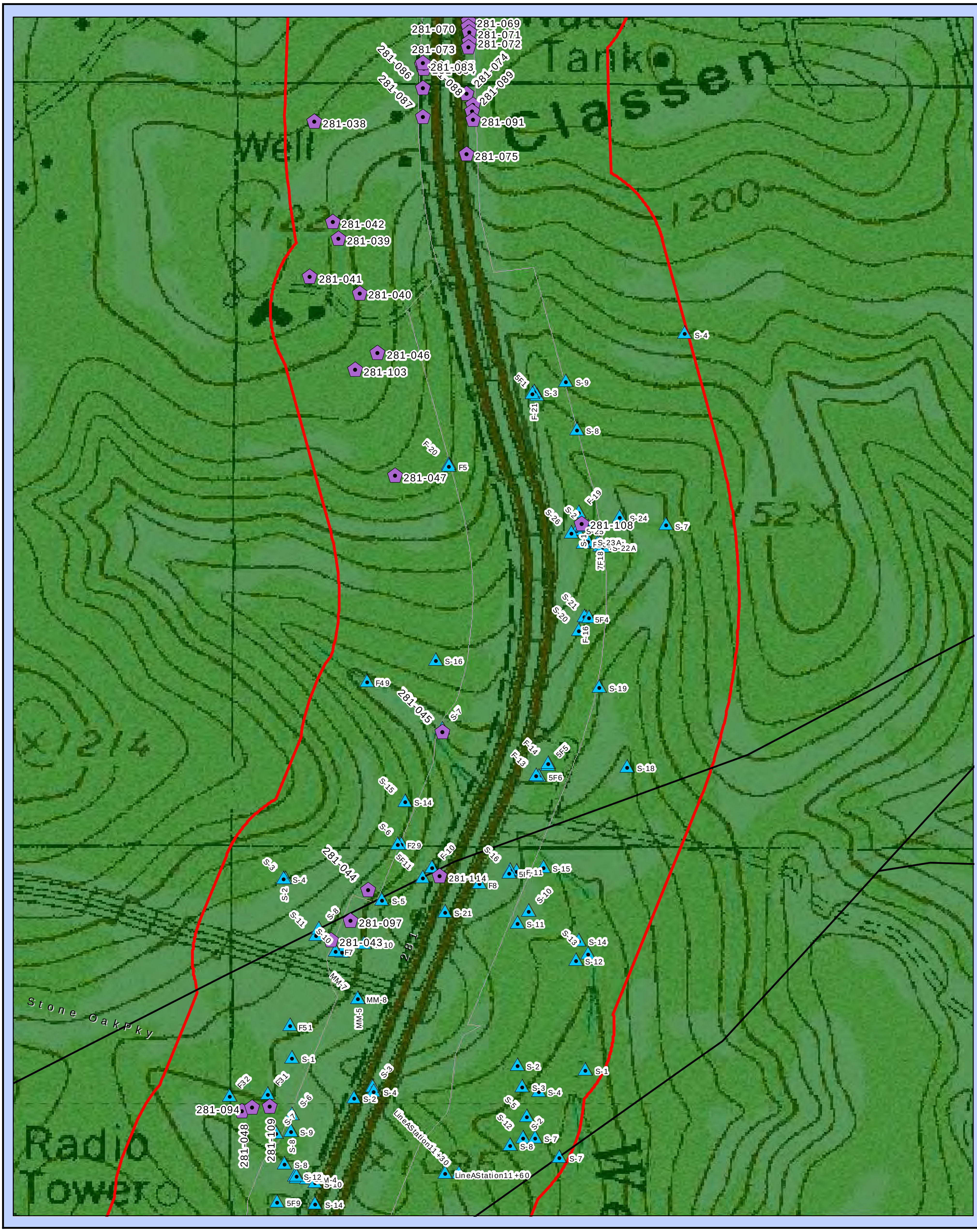


N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC



F-4, Topographic Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

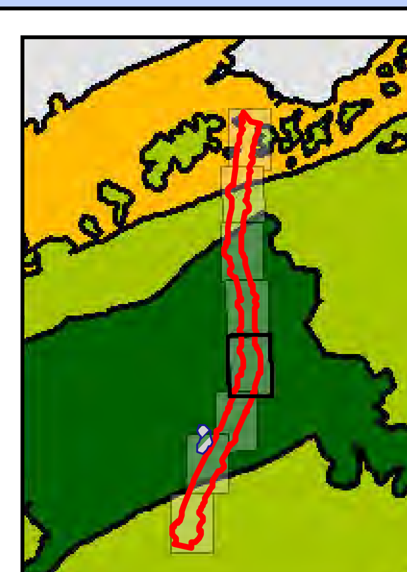
Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

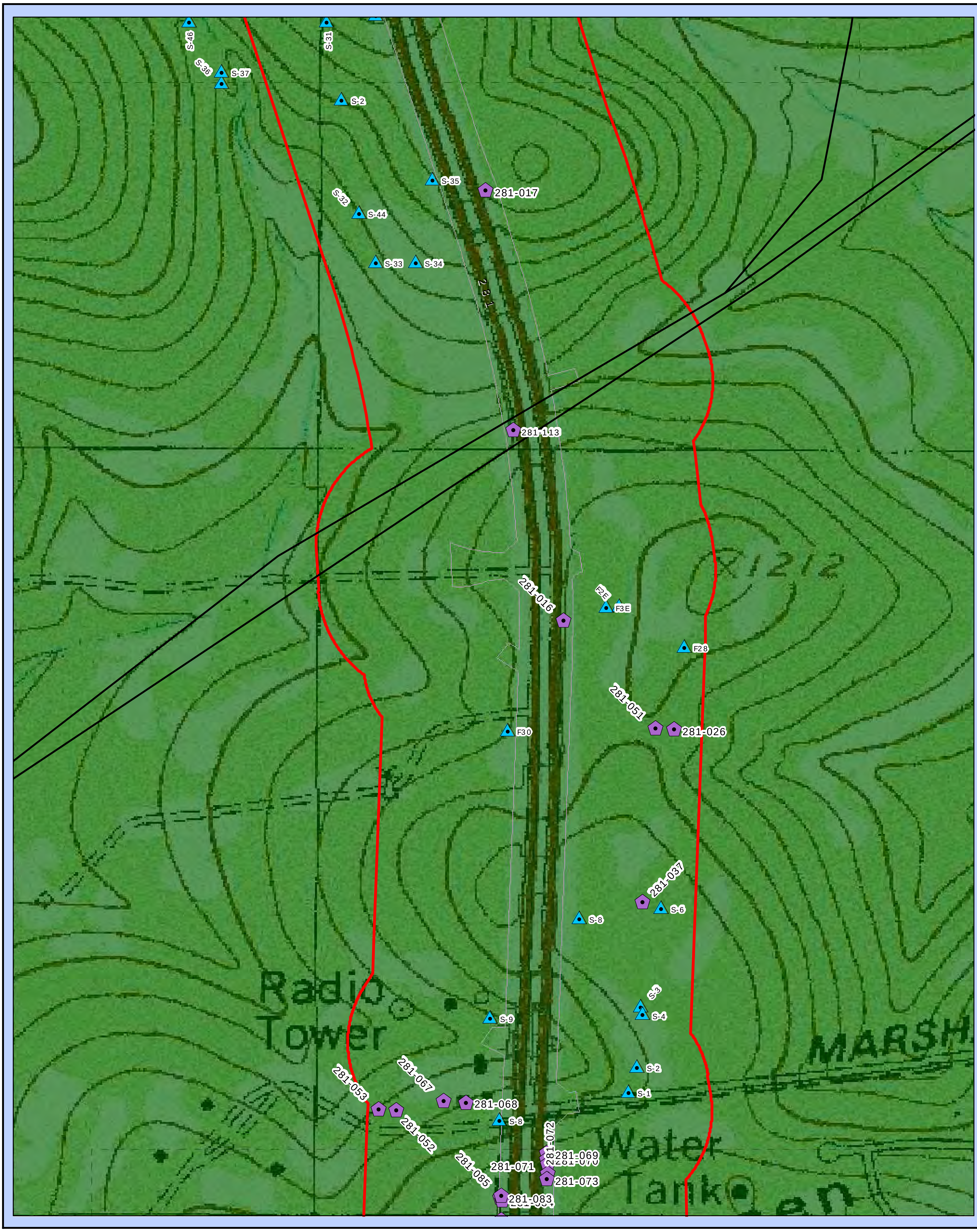
N
W E
S

Meters
0 125 250 500

0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC





F-5, Topographic Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

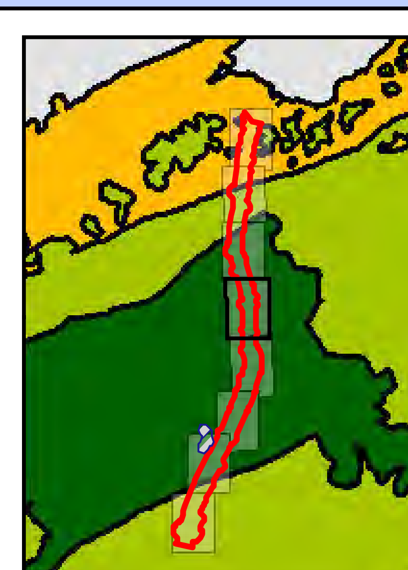
Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

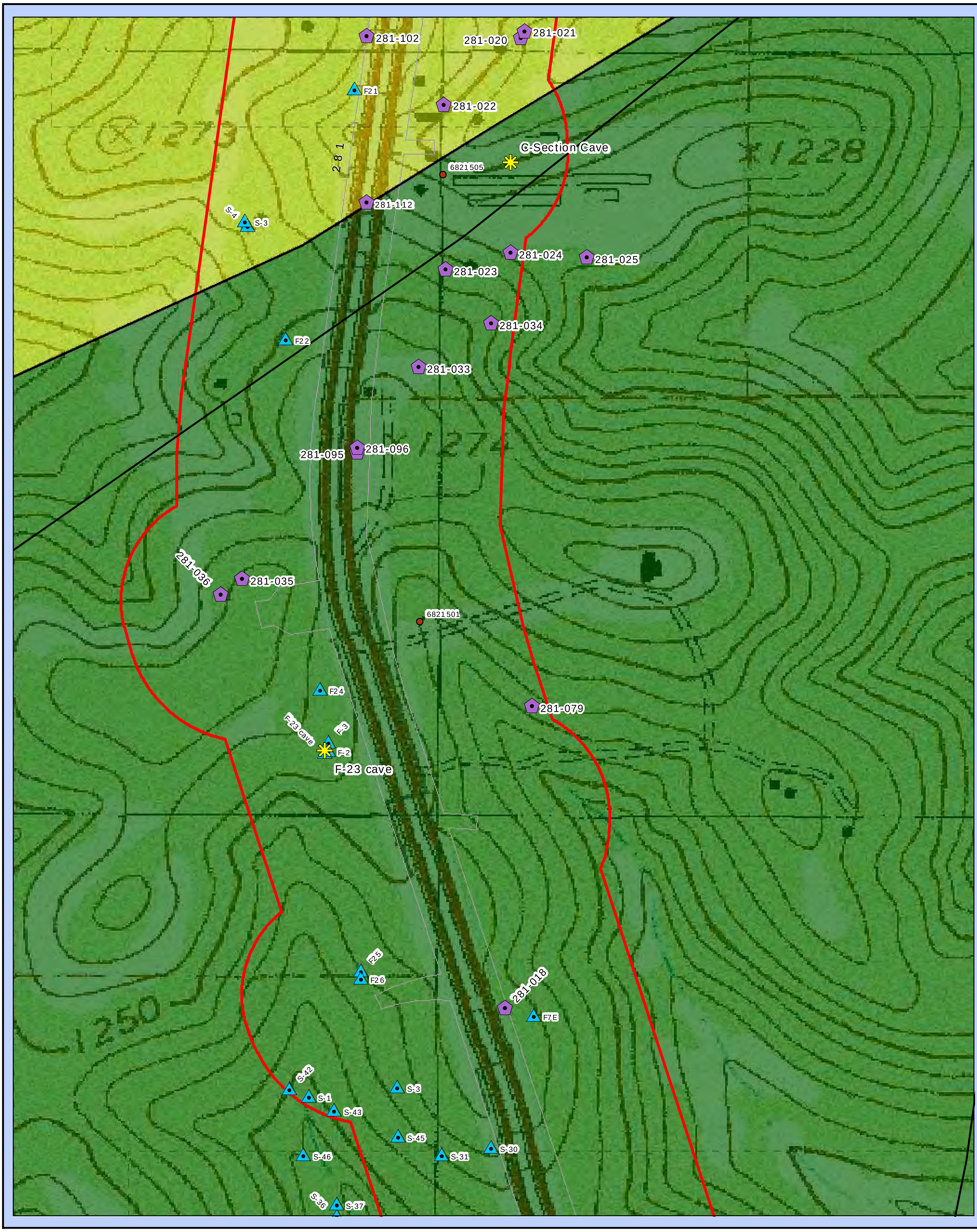
Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

N
W E
S

Meters
0 125 250 500
0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC





F-6, Topographic Map

DRAFT

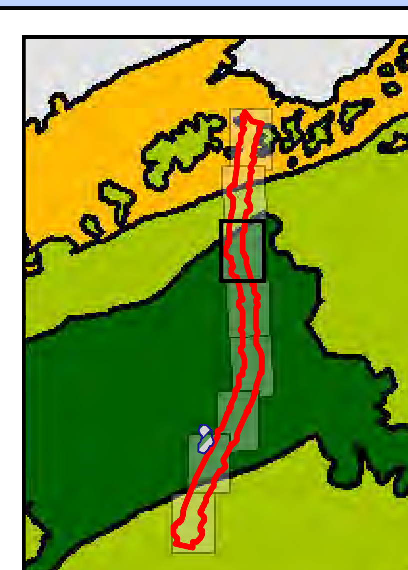
Karst Zones source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

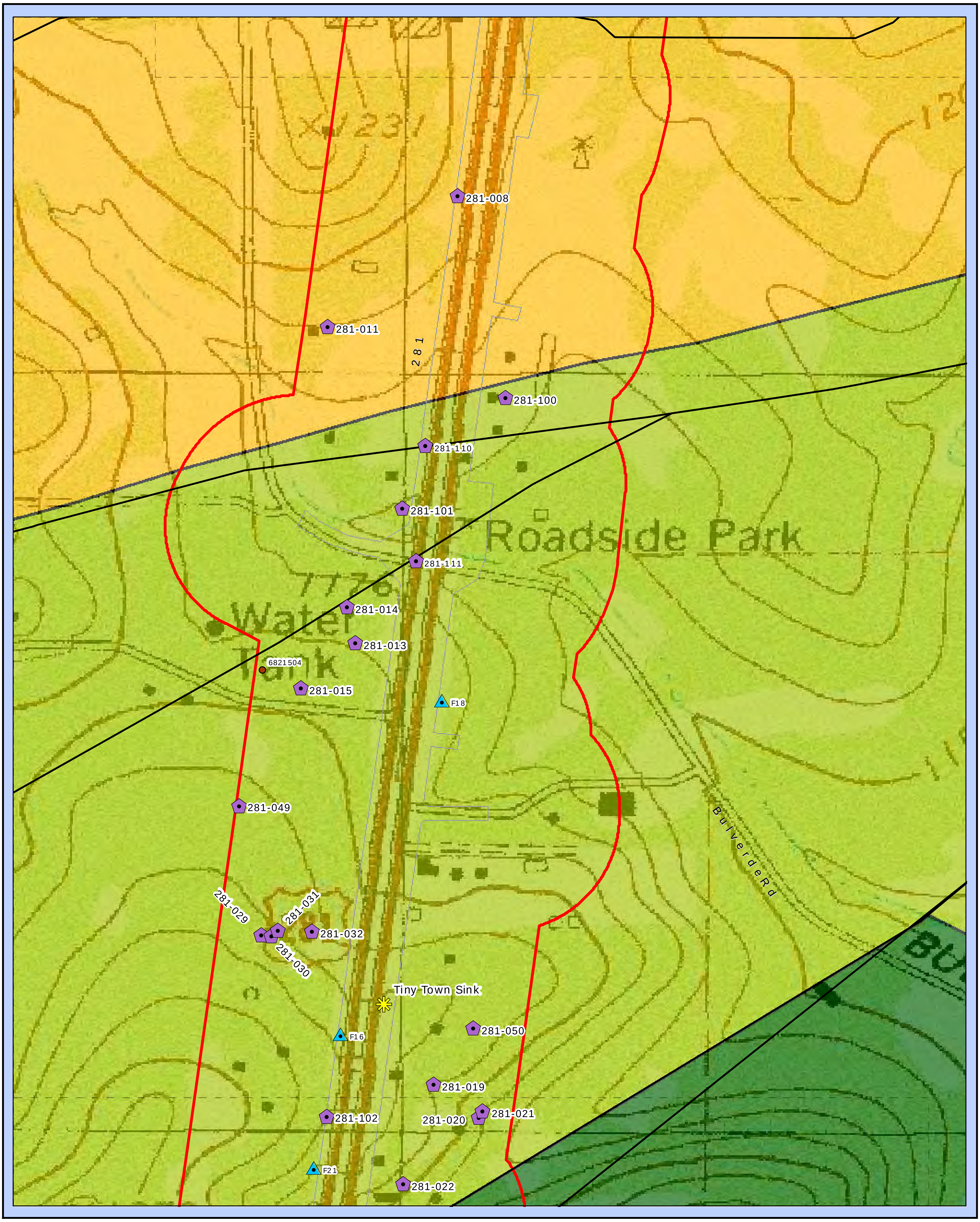
Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

N
W E
S

Meters
0 125 250 500
0 375 750 1,500
Feet



ZARA
ENVIRONMENTAL LLC



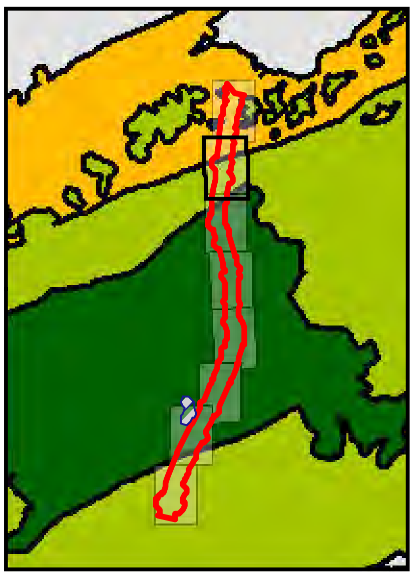
F-7, Topographic Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

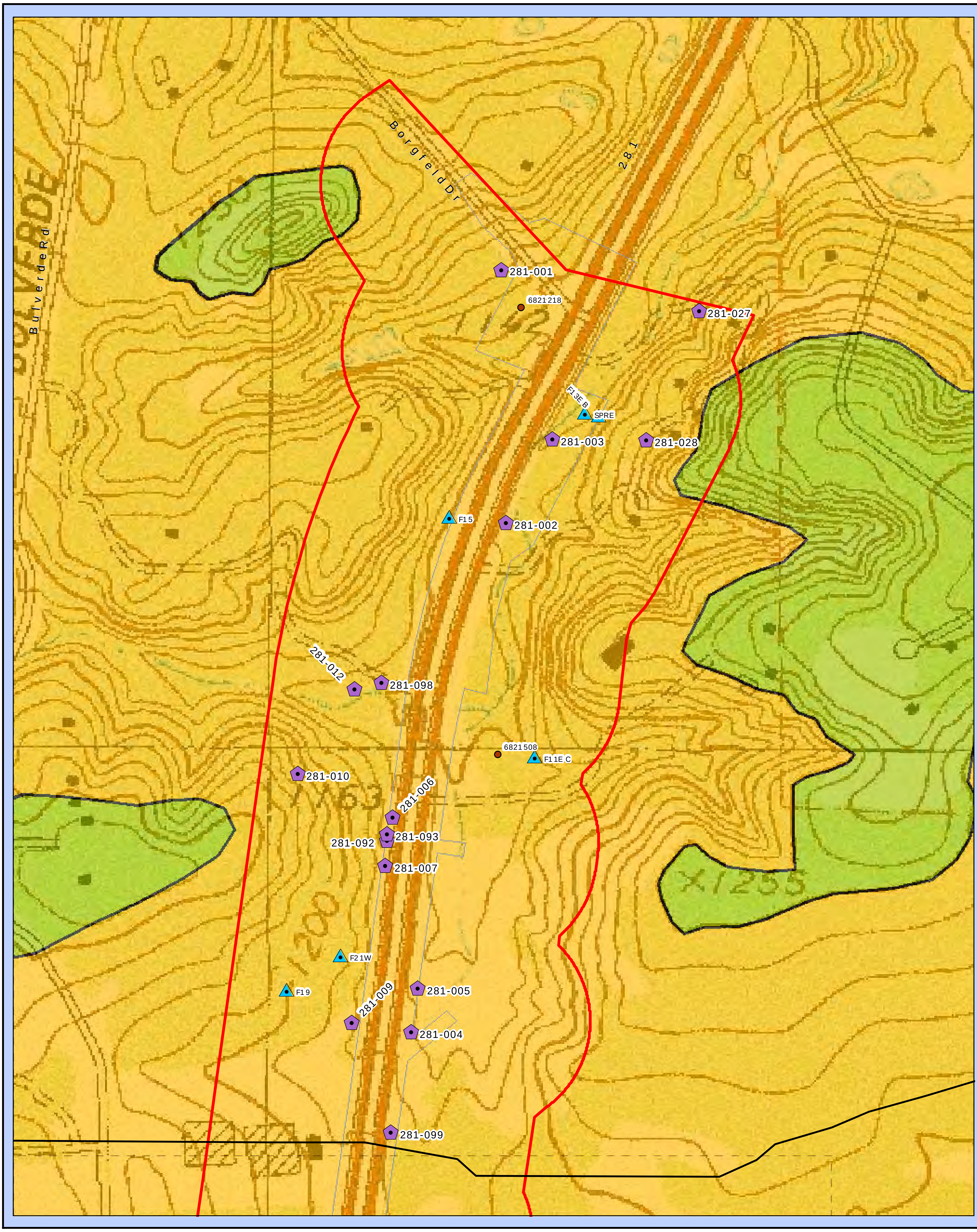
Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit



N W E S

Meters: 0, 125, 250, 500
Feet: 0, 375, 750, 1,500

ZARA ENVIRONMENTAL LLC



F-8, Topographic Map

DRAFT

Karst Zones source: U.S. Fish and Wildlife Service, 2007
Topographic data source: USGS SIM 2873, 2005

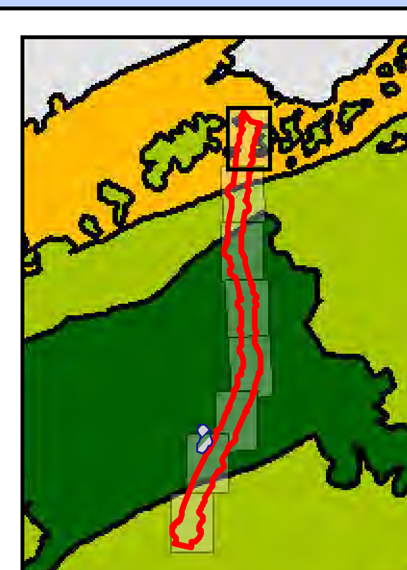
Surveyed Features
Historic Features
Historic Caves (TSS)
Wells
Study Area
plate extents
Faults

Karst Zones
Zone 1 - Endangered species known to occur
Zone 2 - Endangered species likely to occur
Zone 3 - Endangered species probably do not occur
Zone 4 - Area which requires further research
Critical habitiat Unit

N
W E
S

Meters
0 125 250 500
0 375 750 1,500
Feet

ZARA
ENVIRONMENTAL LLC



DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX G

TAXONOMIC VERIFICATION LETTERS

IDENTIFICATIONS OF SPECIMENS FROM KARST FEATURES ALONG U.S. 281, BEXAR COUNTY, TEXAS

James R. Reddell

10 August 2010

Karst Feature 281-056

20 May 2010. P. Sprouse.

Centipedes: Scutigeridae genus and species (1)

Karst Feature 181-062

3 June 2010. J. Larsen.

Harvestmen: Opiliones undetermined (1) (accidental)
Subterranean silverfish: Nicoletiidae genus and species(very small, slender) (1) (?troglobite)

14 June 2010. P. Sprouse.

Terrestrial isopods: ?*Brackenridgia* (1) (troglobite)
Spiders: Araneae undetermined (1)
Harvestmen: Opiliones undetermined (1) (accidental)
Opiliones (1 exoskeleton) (1)
Chinquipellobunus sp. (1) (troglobite)

29 June 2010. P. Sprouse, P. Bryant.

Terrestrial isopods: ?*Brackenridgia* sp. (1) (troglobite)
Harvestmen: Opiliones undetermined (1) (accidental)
Millipedes: *Cambala speobia* (1) (troglobite)

Karst Feature 281-063

14 June 2010. P. Sprouse.

Terrestrial isopods: ?*Brackenridgia* sp. (4) (troglobite)
Slender diplurans: Campodeidae genus and species (2)

23 June 2010. Paul Bryant.

Slender diplurans: Campodeidae genus and species (1)

23 June 2010. P. Sprouse.

Harvestmen: *Leiobunum townsendii* (1) (trogloxene)

25 June 2010. J. Larsen, P. Sprouse.

Harvestmen: *Leiobunum townsendii* (1) (trogloxene)

Karst Feature 281-070

17 June 2010. P. Bryant, B. Larsen.

Spiders: ?*Cicurina varians* (1 im) (troglophile)
Harvestmen: *Texella* (eyeless, very long legs) (1) (troglobite)

25 June 2010. J. Larsen, P. Sprouse.

Spiders: Araneae undetermined (1)
Subterranean silverfish: *Texoreddellia* sp. (1) (stuck in glue) (troglobite)

Karst Feature 281-071

16 June 2010. P. Sprouse.

Terrestrial isopods: ?*Brackenrdgia* sp. (1) (troglobite)
Spiders: Araneae undetermined sp. 1 (1)
Araneae undetermined sp. 2 (1)

Karst Feature 281-073 (=Cool Cave)

18 June 2010. K. McDermid.

Slender springtails: Entomobryomorpha undetermined(1)

25 June 2010. J. Karsen, P. Sprouse.

Spiders: ?*Cicurina varians* (1 female) (troglophile)
Subterranean silverfish: *Texoreddellia* sp. (1) (troglobite)

Karst Feature 281-075

15 June 1010. P. Bryant, B. Larsen.

Spiders: ?*Cicurina varians* (4) (troglophile)

Karst Feature 281-078

21 June 2010. Paul Bryant.

Centipedes: Geophilomorpha undetermined (1)
Lithobiidae genus and species (1)

Karst Feature 281-080 (=Power Pole Hole)

15 May 2010. P. Bryant.

Spiders: Araneae undetermined sp. 1 (1)
Araneae undetermined sp. 2 (1)
Araneae undetermined sp. 3 (1)
?*Cicurina varians* (2 im) (troglophile)

20 May 2010. P. Sprouse.

Scorpions: ?*Pseudouroctonus reddelli* (1 juv) (troglophile)
Spiders: Araneae undetermined (1)
?*Cicurina varians* (2 im) (troglophile)
Centipedes: Geophilomorpha undetermined (1)
Slender springtails: Entomobryomorpha undetermined (1)
Cave crickets: *Ceuthophilus* (*Geotettix*) *cunicularis* (1) (troglophile)

11 June 2010. P. Sprouse.

Snails: *Helicodiscus* sp. (2) (troglophile)
Terrestrial isopods: ?*Brackenridgia* sp. (11) (troglobite)
Spiders: Araneae undetermined (3 spp.) (10)
Araneae undetermined (blind) (2 spiderlings)
?*Cicurina varians* (1 female, 3 im.) (troglophile)
Pseudoscorpions: Pseudoscorpionida undetermined (eyeless) (1)
Harvestmen: *Chinquipellobunus* sp. (2) (troglobite)
Hot house millipedes: *Oxidus gracilis* (1)
Slender springtails: Entomobryomorpha undetermined (2)
Subterranean silverfish: *Texoreddellia* sp. (4) (troglobite)
Cave crickets: *Ceuthophilus* sp. (nymphs) (3)
Beetles: Coleoptera undetermined (1 larva)
Rove beetles: Staphylinidae genus and species (1)

12 June 2010. P. Bryant.

Terrestrial isopods: ?*Brackenridgia* sp. (2) (troglobite)
Spiders: Araneae undetermined sp. 1 (8 eyes) (1 female)
Araneae undetermined sp. 2 (6 eyes) (1 im)

17 June 2010. Paul Bryant, Bill Larsen.

Spiders: ?*Cicurina varians* (1 im) (troglophile)
Subterranean silverfish: *Texoreddellia* sp. (2) (troglobite)

17 June 2010. Bill Larsen.

Terrestrial isopods: *Brackenridgia* sp. (1) (troglobite)

Subterranean silverfish: *Texoreddellia* sp. (1) (troglobite)

18 June 2010. K. McDermid.

Snails: Gastropoda undetermined (1)
Spiders: Araneae undetermined (2)
Cicurina varians (1 female) (troglophile)
Harvestmen: *Chinquipellobunus* sp. (1) (troglobite)
Cave crickets: *Ceuthophilus* sp. (1 nymph)

29 June 2010. P. Sprouse, P. Bryant.

Terrestrial isopods: ?*Brackenridgia* sp. (1) (troglobite)
Spiders: ?*Cicurina varians* (3 im) (troglophile)
Centipedes: Lithobiidae genus and species (1)
Subterranean silverfish: *Texoreddellia* sp. (1) (troglobite)

Karst Feature 281-083 (=Dripstone Cave)

14 June 2010, P. Sprouse.

Spiders: Araneae undetermined (eyeless) (1 male) (troglobite)
Araneae undetermined (eyed) (1)
?*Cicurina varians* (4 im) (troglophile)
Harvestmen: *Leiobunum townsendii* (1) (trogloxene)
Slender springtails: Entomobryomorpha undetermined(4)
Cave crickets: *Ceuthophilus* sp. (1 nymph)

21 June 2010. P. Sprouse.

Spiders: Araneae undetermined (2)
?*Cicurina varians* (7 im) (troglophile)

29 June 2010. P. Sprouse, P. Bryant.

?Terrestrial flatworm: ? Tricladida-Terricola undetermined (1)
Spiders: ?*Cicurina varians* (3 im) (troglophile)
Ground beetles: Carabidae genus and species (1)

21 June 2010. P. Sprouse.

Spiders: Araneae undetermined (2)
?*Cicurina varians* (7 im) (troglophile)

Karst Feature 281-084

18 June 2010. Tony Galvan,

Paul Bryant.

Spiders: Araneae udetermined (1)
?*Cicurina varians* (2 im) (troglophile)
Subterranean silverfish: Nicoletiidae genus and species (1)
Ground beetles: Carabidae genus and species (1)

Karst Feature 281-085

18 June 2010. Ellie Watson.

Centipedes: Cryptopidae (?*Theatops* sp.) (1) (?troglobite)

U.S. 281 Identifications

281-005
    ZARA 6057 – 10 Sept. 2010. P. Sprouse.
        Araneae (eyed) (1 penultimate male)
        ?*Cicurina* (eyed) (3 imm.)
    ZARA 6058 – 10 Sept. 2010. P. Sprouse.
        Araneae (eyed) (1 imm)

281-011
    ZARA 6157 – 10 Aug. 2010. K. McDermid.
        Parajulidae (1 female, 1 im) – ZARA as Diplopoda
    ZARA 6158 – 10 Aug. 2010. K. McDermid.
        Geophilomorpha (1) – ZARA as Scolopendromorpha
    ZARA 6159 – 10 Aug. 2010. K. McDermid.
        Cicurina (eyed) (3 im)
        ?*Cicurina* (eyed) (1 im)
        Araneae (eyed) (1 female) – not *Cicurina*
    ZARA 6160 – 10 Aug. 2010. K. McDermid.
        Araneae (eyed) (1 im)
    ZARA 6161 – 10 Aug. 2010. K. McDermid.
        Acarina (1)
281-013
    ZARA 6052 – 11 Aug. 2010. K. McDermid
        Geophilomorpha (1)
    ZARA 6053 – 11 Aug. 2010. K. McDermid
        Araneae eyed (?2 spp.) (2 imm.) – ZARA as *Cicurina* but not sure

281-026
    ZARA 6071 – 10 Sept. 2010. P. Sprouse.
        Cicurina (eyed) (2) – ZARA as *Cicurina varians* (prob. right)
    ZARA 6072 – 10 Sept. 2010. P. Sprouse.
        Geophilomorpha (1)

281-037
    ZARA 6076 – 15 Sept. 2010. J. Larsen.
        Reduviidae (2)
    ZARA 6077 – 15 Sept. 2010. J. Larsen.
        Porcellio (2) – ZARA as terrestrial isopoda
    ZARA 6078 – 15 Sept. 2010. J. Larsen.
        Araneae (1 im)
    ZARA 6079 – 15 Sept. 2010. J. Larsen.
        ?*Cicurina* (4 im)
    ZARA 6080 – 15 Sept. 2010. J. Larsen.
        Zygentoma-Nicoletiidae (not *Texoreddellia*) – ZARA as *Brackenridgia*
    ZARA 6081 – 15 Sept. 2010. J. Larsen.

Campodeidae – ZARA as dipluran
ZARA 6093 – 24 Sept. 2010. J. Larsen.
?*Cicurina* (eyed) (1 im)

281-045
ZARA 6075 – 4 Aug. 2010. J. Larsen.
Carabidae (1) – ZARA as Coleoptera (eyed)
ZARA 6101 – 24 Sept. 2010. J. Larsen.
?*Cicurina* (1 im) – ZARA as *Cicurina varians*
ZARA 6102 – 24 Sept. 2010. J. Larsen.
Isopoda-Oniscoidea (1 eyed) – ZARA as *Brackenridgia*
(not a Trichoniscidae but have never seen it and
can't get it to key out because of size)

281-070
ZARA 6059 – 1 Sept. 2010. K. McDermid
Araneae (1 blind immature)
ZARA 6114 – 16 Sept. 2010. K. McDermid
Acarina (1)

281-071
ZARA 6105 – 16 Sept. 2010. K. McDermid.
Mymeleontidae (1 nymph)

281-073
ZARA 5639 – 16 June 2010. J. Larsen
Chinquipellobunus (1)
ZARA 6048 – 1 Sept. 2010. K. McDermid
?*Cicurina* (eyed) (1 im)
ZARA 6049 – 1 Sept. 2010. K. McDermid
?*Brackenridgia* (1)
ZARA 6050 – 18 June 2010. K. McDermid
Ceuthophilus sp. (2 im) – ZARA as *Ceuthophilus secretus* but
one is probably *C.* sp. B and the other too small to i.d.
ZARA 6092 – 15 June 2010. B. Larsen.
Ceuthophilus sp. (1 im)

281-080
ZARA 6113 – 16 Sept. 2010. P. Sprouse.
?*Cicurina* (eyed) (1) – ZARA as *Cicurina varians*

281-085
ZARA 6054 – 25 June 2010. P. Sprouse.
Ceuthophilus cunicularis (1)
ZARA 6055 – 25 June 2010. P. Sprouse.
Araneae eyed (1 im) –ZARA as *Cicurina* (eyed) but may not be

ZARA 6103 – 16 Sept. 2010. K. McDermid.
?*Cicurina* (eyed) (2 im) – ZARA as *Cicurina varians*
ZARA 6104 – 16 Sept. 2010. K. McDermid.
Ceuthophilus sp. (1 nymph)

281-090
ZARA 6058 – 26 Aug. 2010. K. McDermid
Texoreddellia (1)
ZARA 6112 – 16 Sept. 2010. P. Sprouse.
Entomobryomorpha (1) – ZARA as Collembola

281-095
ZARA 6156 – 14 Oct. 2010. P. Sprouse.
?*Cicurina* (1 im) – ZARA as *Cicurina varians*

281-080
Power Pole Hole
ZARA 6056 – 19 Aug. 2010. P. Sprouse.
Cicurina (eyed) – 1 immature
Araneae (eyed) – 3 females, 1 male – ZARA as *Cicurina* but probably not
ZARA 6057 – 19 Aug. 2010. P. Sprouse.
Chinquipellobunus (1)
ZARA 6060 – 14 Sept. 2010. J. Larsen.
Cambala speobia (1)
ZARA 6061 – 14 Sept. 2010. J. Larsen.
Ceuthophilus sp. (1 nymph) – ZARA as *Ceuthophilus cunicularis*
ZARA 6062 – 14 Sept. 2010. J. Larsen.
Chinquipellobunus (1)
ZARA 6063 – 14 Sept. 2010. J. Larsen.
?*Brackenridgia* (1)
ZARA 6065 – 14 Sept. 2010. J. Larsen.
?*Cicurina* (6-eyed) (1 im)
ZARA 6066 – 14 Sept. 2010. J. Larsen.
Araneae (1 im)
ZARA 6098 – 24 Sept. 2010. J. Larsen.
?*Brackenridgia* (1)
ZARA 6107 – 16 Sept. 2010. P. Sprouse, K. McDermid.
Cambala speobia (3)
Araneae (1 penultimate male) – in vial with *Cambala speobia*
ZARA 6108 – 16 Sept. 2010. P. Sprouse, K. McDermid.
Ceuthophilus cunicularis (2)
ZARA 6110 – 16 Sept. 2010. P. Sprouse, K. McDermid.
Chinquipellobunus (1 im)
ZARA 6111 – 16 Sept. 2010. P. Sprouse, K. McDermid.
Campodeidae (1) – ZARA as Dipluran

281-025
Taco Truck Hole

ZARA 6094 – 24 Sept. 2010. J. Larsen.

Ceuthophilus sp. B – ZARA as *Ceuthophilus secretus*

ZARA 6095 – 24 Sept. 2010. J. Larsen.

Helicodiscus (1)

ZARA 6096 – 24 Sept. 2010. J. Larsen.

?*Cicurina* (1 im)

ZARA 6097 – 24 Sept. 2010. J. Larsen.

Cambala speobia (1)

ZARA 6106 – 17 Sept. 2010. P. Sprouse.

Texoreddellia (1)

NOTE: 1 hr.

Krista McDermid
Biologist/Project Manager
Zara Environmental LLC
1707 W. FM 1626
Manchaca, Texas 78652

21 November 2010

Re: Identification of *Texella* species from Bexar Co., 281-070 (ZARA 5662)

Dear Krista,

I have examined the specimen of *Texella* from locality “281-070”.

Although the specimen is an adult male, it has not been possible to study the most informative set of characters, the genitalia, as they were strongly retracted and resisted expansion. Consequently, the conclusions drawn are based only on somatic features as observed at a maximum magnification of 100X through a stereo light microscope.

Of the described species, this male is closest to *T. tuberculata*, with which it agrees in several characters: tarsal count, eye mound size and tuberculation, size of the secondary sexual structures, and general appearance.

However, the specimen also presents some differences from *T. tuberculata*: the presence of anterior tubercles on the scute, a larger number of spinose tubercles on the eye mound, and a slightly larger postopercular process.

Although these differences suggest that this specimen may represent a different species, it may also represent somatic variation within *T. tuberculata*. It is not possible to determine which of these possibilities is true without studying additional material, especially a male with expanded genitalia, and a closer examination of both the somatic and genitalic morphology with a scanning electron microscope.

For the present, I would regard this specimen, with some uncertainty, as *Texella ?tuberculata*.

Sincerely,

Darrell Ubick
Department of Entomology
California Academy of Sciences
55 Music Concourse Drive
Golden Gate Park
San Francisco CA 94118
dubick@calacademy.org

TEXAS TECH UNIVERSITY
Museum of Texas Tech University

30 Nov. 2010

REPORT

Dr. Jean Krejca
& Peter Sprouse
Zara Environmental LLC
1707 W. Fm. 1626
Manchaca, Texas 78652

The spider from Power Pole Hole, Bexar County, Texas, that was submitted for identification has now been studied. The female is *Cicurina bullis* Cokendolpher, 2004. The identification is based upon examination of the internal genital structures with light microscopy. This eyeless species is a troglobite and previously only known from Camp Bullis. This is a significant discovery because of the new location for this species, which has a very limited distribution. The specimen collected 16 Sept. 2010 by P. Sprouse and K. McDermid has the catalog number Zara-6109 and is in 95% ethanol.

Sincerely,

James C. Cokendolpher

James C. Cokendolpher
Research Scientist / Assistant Curator
Invertebrate Zoology
Natural Science Research Laboratory
Lubbock, Texas 79409
cell phone 806-470-4190

DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX H

CLIMATE ANALYSIS

Climate parameters for biological surveys

Recommended season and weather parameters

The USFWS (2006) recommends season and weather parameters for performing karst invertebrate presence/absence surveys. These are:

1) Spring (March through June) or fall (September through January)
2) Average weather (temperature and rainfall) for time of year.
3) Surface air temperatures during the previous week should not have been greater than 37.8 degrees C (100 degrees F) or less than 4.4 degrees C (40 degrees F).
4) Lack of drought conditions.
5) Recent rainfall.
6) Absence of recent, extensive, local flooding.

During this study, presence/absence surveys for federally listed karst invertebrates were performed at features 281-025, 037, 045, 062, 063, 070, 071, 073, 080, 083, 085, 088, and 090. Climate conditions were analyzed to ensure that the above parameters were adhered to as strictly as possible for each survey, and the results of those analyses are discussed for each feature below.

Table 1 displays the high and low temperatures and rainfall amount for seven days preceding each survey and the survey date. All of the surveys were completed within the spring or fall seasons (defined as March through June and September through January, respectively), as recommended by USFWS (2006), therefore the first climate criterion is satisfied for all surveys.

Table 1. Climate parameters at least one week in advance of each survey date. Survey dates are indicated in bold, and the features surveyed are indicated in the right hand columns.

Date	Temp (°C)		Rain (cm)	Feature(s) Surveyed (281 Feature ID suffix)												
2010	high	low	total	025	037	045	062	063	070	071	073	080	083	085	088	090
7-Jun	34	25	0													
8-Jun	29	22	0													
9-Jun	32	23	0													
10-Jun	34	26	0													
11-Jun	33	26	0													
12-Jun	33	26	0													
13-Jun	34	26	0													
14-Jun	**34**	**25**	**0**				**x**						**x**			
15-Jun	33	24	0													
16-Jun	34	25	0													
17-Jun	33	23	0													
18-Jun	**34**	**26**	**0**						**x**	**x**	**x**					
19-Jun	34	26	0													
20-Jun	33	24	0													
21-Jun	**34**	**24**	**0**				**x**						**x**			

Date	Temp (°C)		Rain (cm)	Feature(s) Surveyed (281 Feature ID suffix)												
2010	high	low	total	**025**	**037**	**045**	**062**	**063**	**070**	**071**	**073**	**080**	**083**	**085**	**088**	**090**
22-Jun	34	24	0													
23-Jun	34	24	0													
24-Jun	35	24	0													
25-Jun	**35**	**25**	**0**					**x**	**x**	**x**	**x**			**x**	**x**	
26-Jun	34	26	0													
27-Jun	35	25	0													
28-Jun	36	23	0													
29-Jun	**33**	**24**	**0**				**x**						**x**			
25-Aug	36	26	0													
26-Aug	34	26	0													
27-Aug	36	22	0													
28-Aug	36	19	0													
29-Aug	34	23	0.18													
30-Aug	37	27	0													
31-Aug	36	26	0													
1-Sep	**37**	**26**	**0**			**x**		**x**	**x**	**x**	**x**			**x**	**x**	**x**
2-Sep	37	23	0.05													
3-Sep	30	21	4.27													
4-Sep	33	22	0													
5-Sep	33	22	0													
6-Sep	33	23	0													
7-Sep	26	23	9.37													
8-Sep	33	23	7.19													
9-Sep	**33**	**26**	**0**					**x**	**x**	**x**	**x**		**x**	**x**	**x**	**x**
10-Sep	32	25	0													
11-Sep	33	25	0													
12-Sep	**33**	**24**	**0**			**x**	**x**	**x**								
13-Sep	33	24	0													
14-Sep	33	25	0													
15-Sep	34	24	0													
16-Sep	**33**	**23**	**0**						**x**	**x**	**x**	**x**	**x**	**x**	**x**	**x**
17-Sep	**34**	**22**	**0.71**	**x**	**x**											
18-Sep	29	22	0.38													
19-Sep	28	21	0.64													
20-Sep	28	21	0.08													
21-Sep	31	22	0													
22-Sep	30	22	0													
23-Sep	31	24	0													
24-Sep	**32**	**23**	**0**	**x**	**x**	**x**		**x**				**x**				
25-Sep	32	22	0													
26-Sep	30	19	0													

Date	Temp (°C)		Rain (cm)	Feature(s) Surveyed (281 Feature ID suffix)												
2010	high	low	total	025	037	045	062	063	070	071	073	080	083	085	088	090
27-Sep	27	14	0													
28-Sep	31	11	0													
29-Sep	32	16	0													
30-Sep	31	15	0													
1-Oct	**31**	**24**	**0**	x	x							x				

The monthly temperature and precipitation levels for one month preceding surveys and the survey months in 2010 were compared with the 30 year average, which was obtained from the National Oceanic and Atmospheric Administration (NOAA). The average temperatures and precipitation levels for 2010 survey months were similar to the 30 year average temperatures and precipitation levels for those months, and well within the range of the historical high and low records (Table 2), therefore the second climate criterion is satisfied for all surveys. Survey specific climate averages are detailed below.

Table 2. Climate summary for San Antonio, showing 30 year temperature and precipitation averages and extremes from 1971-2000.

Month	High (C)	Low (C)	All time High (C)	All time Low (C)	Average Rainfall (cm)	All Time Driest (cm)	All Time Wettest (cm)
June	33	22	41.7	8.9	10.9	Trace	30.35
July	34.8	23.3	41.1	15.6	5.2	0.00	42.98
August	34.8	23.1	42.2	13.9	6.5	0.00	28.30
September	32.2	20.4	43.9	5.0	7.6	0.03	40.08

Temperatures one week prior to each survey were less than 37.8 degrees C (100 degrees F) and greater than 4.4 degrees C (40 degrees F) (Table 1), so the third climate criterion is satisfied.

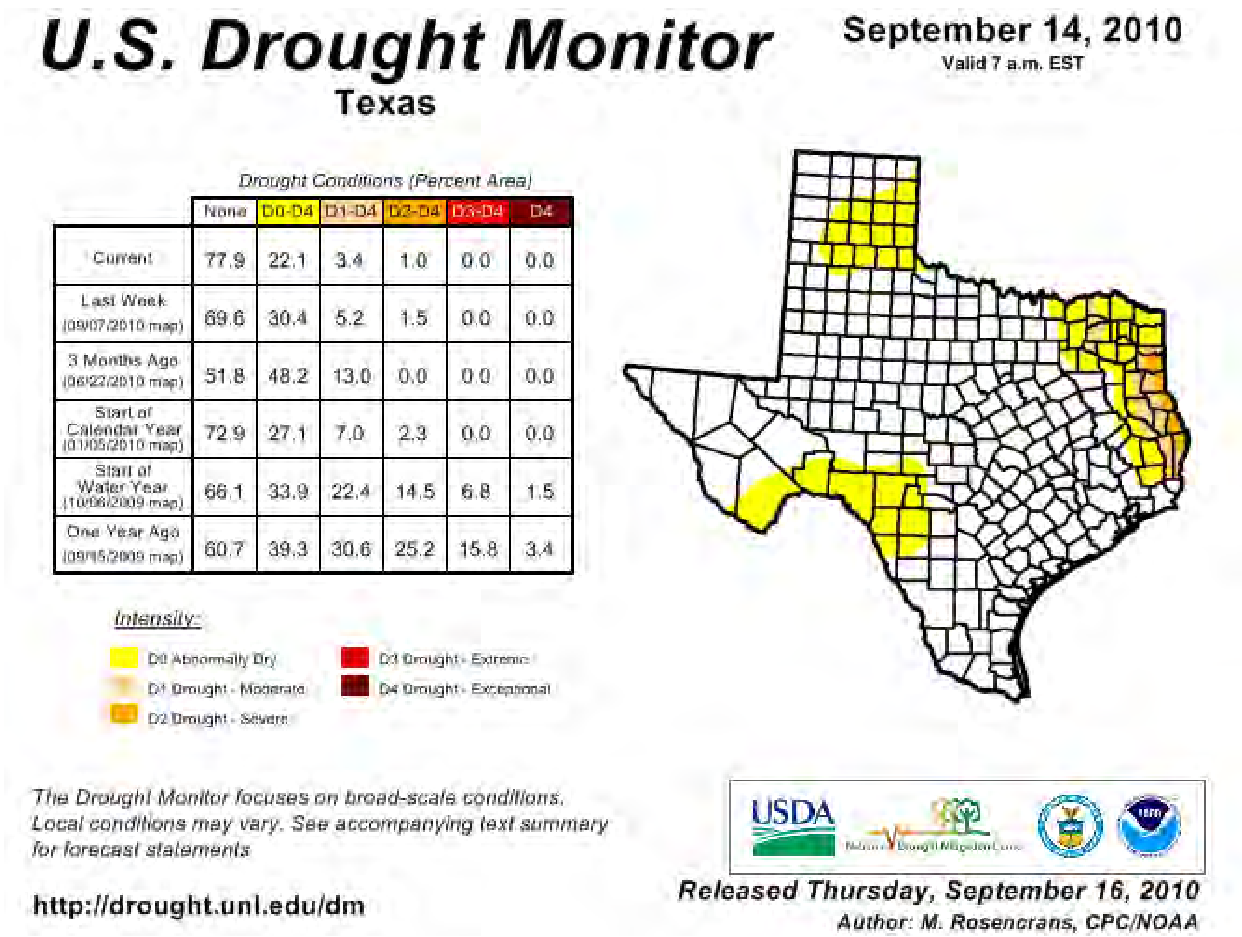
The fourth recommended climate criterion was lack of drought conditions. This criterion was met for all surveys, and is detailed in the survey specific climate discussions below. The fifth parameter is recent rainfall. The amount of rainfall for some survey periods fluctuated from the 30 year average, however in general the survey area did not experience particularly extreme or abnormal climate conditions during 2010. While some surveys were conducted in the absence of rainfall, lack of rain during a given month is not considered abnormal for the area, however the lack of rain in some survey months necessarily leads to the conclusion that this criterion was not satisfied for all surveys.

The sixth parameter is the absence of recent, extensive, local flooding, and is considered satisfied for all surveys. While heavy rain events on 7 and 8 September caused some scheduled surveys to be delayed, there were no conditions that would have obviously classified the survey area as "extensively flooded."

281-025 and 281-037

Surveys for features 281-025 and 281-037 were conducted on September 17, 24, and October 1 of 2010. The average high temperature between 10 September and 1 October was 31.2° C (88.2 °F), the average low was 21.3° C (70.3° F), and the total rainfall was 1.8 cm. The total rainfall of 1.8 cm during the survey period is lower than the normal average rainfall for September, but was preceded by heavy rains on 7 and 8 September, and the total rainfall for the month (13.32 cm) was above average and well within the record precipitation ranges presented in Table 2. This also satisfies the "recent rainfall" criterion above.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1), therefore the fourth climate criterion is satisfied for surveys conducted at these sites.



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	77.9	22.1	3.4	1.0	0.0	0.0
Last Week (09/07/2010 map)	69.6	30.4	5.2	1.5	0.0	0.0
3 Months Ago (06/22/2010 map)	51.8	48.2	13.0	0.0	0.0	0.0
Start of Calendar Year (01/05/2010 map)	72.9	27.1	7.0	2.3	0.0	0.0
Start of Water Year (10/06/2009 map)	66.1	33.9	22.4	14.5	6.8	1.5
One Year Ago (09/15/2009 map)	60.7	39.3	30.6	25.2	15.8	3.4

Figure 1. Texas drought conditions for mid-September, 2010.

281-045

Surveys for feature 281-045 were conducted on September 1, 12 and 24. The average high temperature between 25 August and 24 September was 32.7° C (90.9 °F), the average low was 23.3° C (74.0° F), and the total rainfall was 22.86 cm. The total rainfall of 22.86 cm is higher than the normal average rainfall for August and September; however, the amount of rainfall is still within the precipitation range indicated in Table 2. This also satisfies the "recent rainfall" criterion above.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1 and Figure 2), therefore the fourth climate criterion is satisfied for surveys conducted at this site.

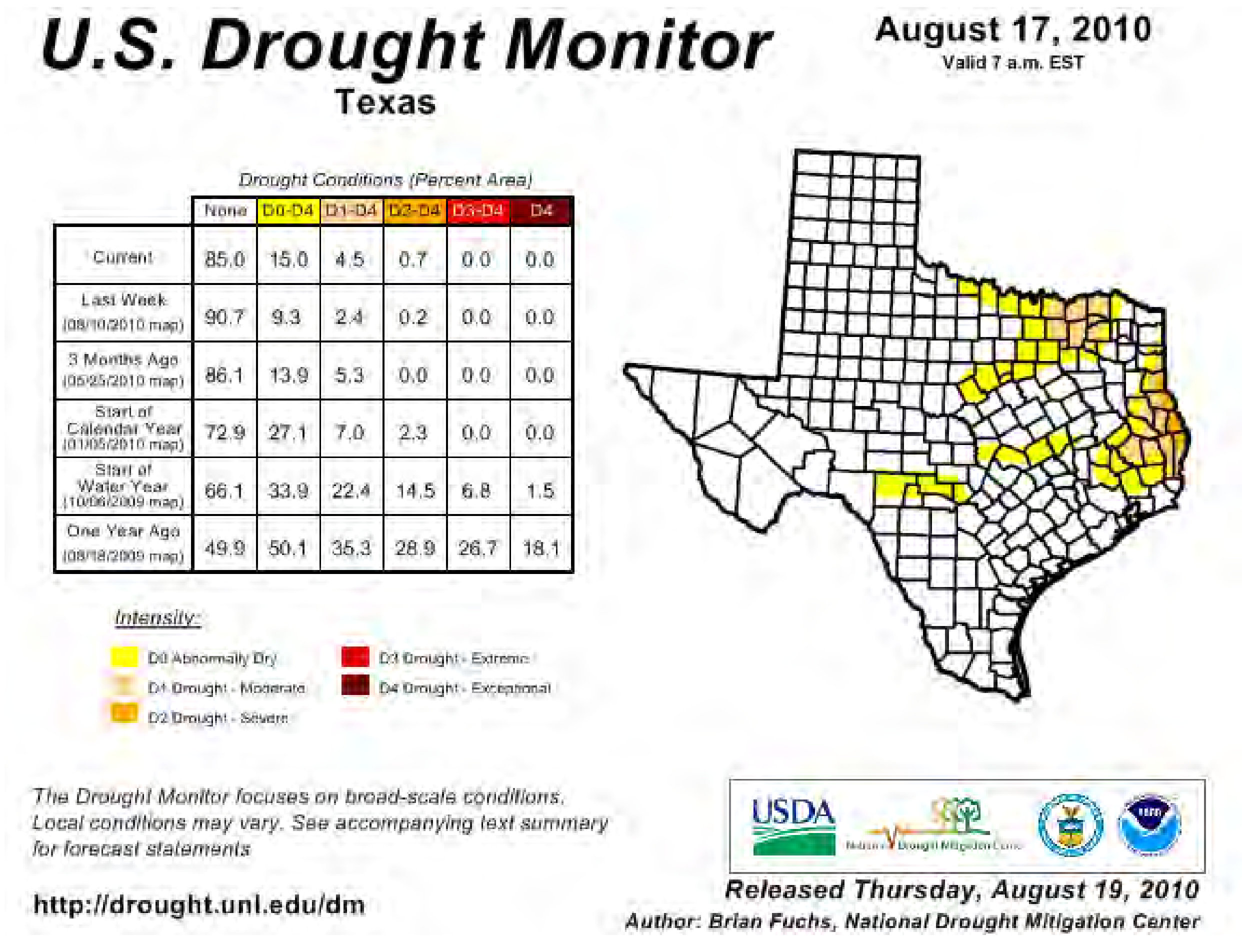
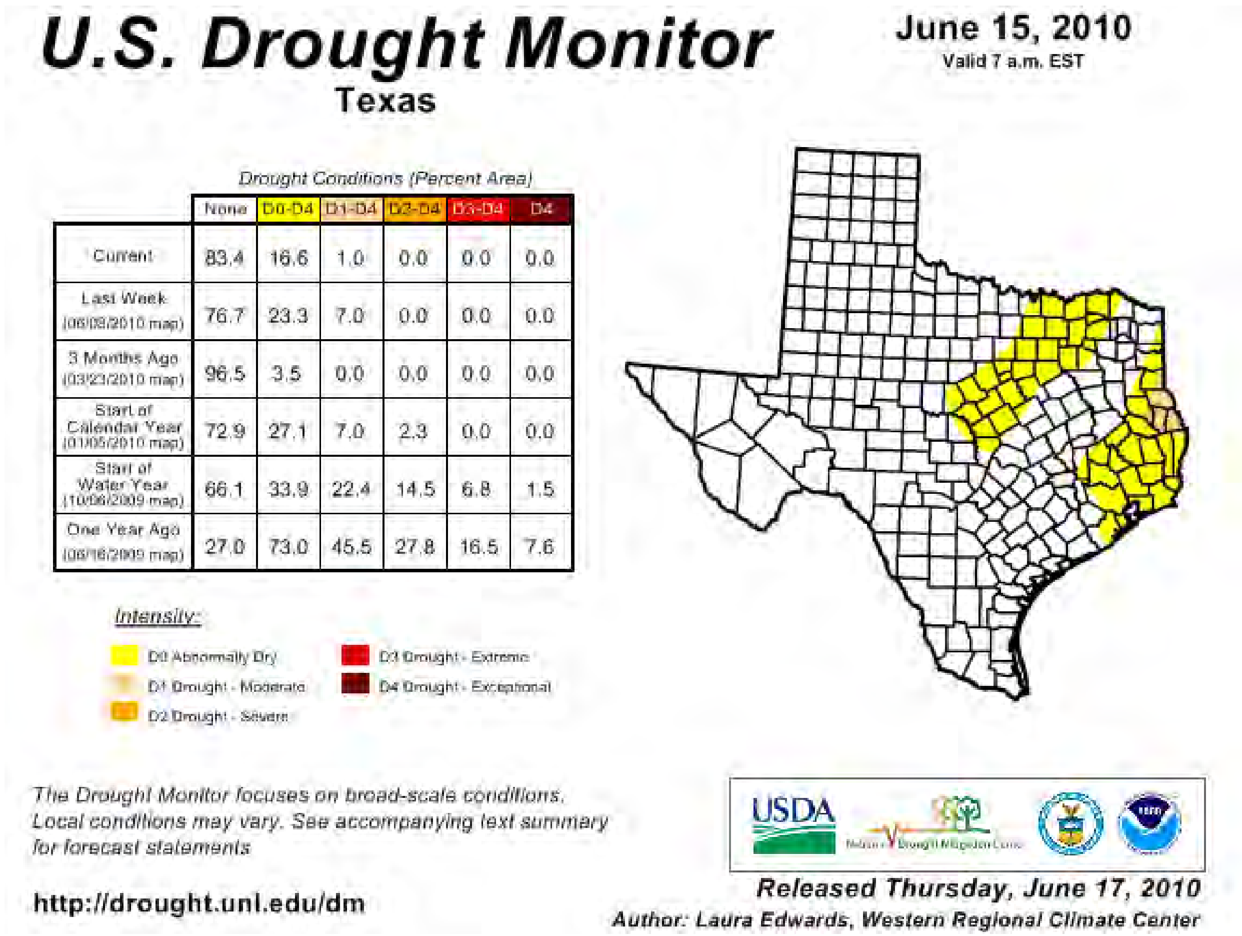


Figure 2. Texas drought conditions for mid-August, 2010.

281-062

Surveys for feature 281-062 were conducted on 14, 21, and 29 June and on 12 September 2010. The average high temperature between 7 June and 29 June was 33.8 °C (92.8 °F), the average low was 24.7 °C (76.5° F), and the total rainfall was 0 cm, thereby these surveys were not in compliance with the "recent rainfall" guideline above. The average high temperature between 5 September and 12 September was 31.9 °C (89.5 °F), the average low was 23.8 °C (74.9° F), and the total rainfall was 16.56 cm, so the "recent rainfall" criterion was satisfied for this survey.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1 and Figure 3), therefore the fourth climate criterion is satisfied for surveys conducted at this site.



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	83.4	16.6	1.0	0.0	0.0	0.0
Last Week (06/08/2010 map)	76.7	23.3	7.0	0.0	0.0	0.0
3 Months Ago (03/23/2010 map)	96.5	3.5	0.0	0.0	0.0	0.0
Start of Calendar Year (01/05/2010 map)	72.9	27.1	7.0	2.3	0.0	0.0
Start of Water Year (10/06/2009 map)	66.1	33.9	22.4	14.5	6.8	1.5
One Year Ago (06/16/2009 map)	27.0	73.0	45.5	27.8	16.5	7.6

Figure 3. Texas drought conditions for mid-June, 2010.

281-063

Surveys for feature 281-063 were conducted on 25 June and on 1, 9, 12, and 24 September 2010. The average high temperature between 17 June and 25 June was 34.1 ^{o}C (93.4 ^{o}F), the average low was 24.6 ^{o}C (76.3^{o} F), and the total rainfall was 0 cm, thereby this survey was not in compliance with the "recent rainfall" guideline above. The average high temperature between 25 August through 24 September was 32.7 ^{o}C (90.9 ^{o}F), the average low was 23.3 ^{o}C (74.0^{o} F), and the total rainfall was 22.86 cm, so the "recent rainfall" criterion was satisfied for these surveys.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1, Figure 2 and Figure 3), therefore the fourth climate criterion is satisfied for surveys conducted at this site.

281-070, 281-071 and 281-073

Surveys for features 281-070, 281-071 and 281-073 were conducted on 18 and 25 June and on 1, 9 and 16 September 2010. The average high temperature between 11 June and 25 June was 33.9 ^{o}C (93.0 ^{o}F), the average low was 24.9 ^{o}C (76.9^{o} F), and the total rainfall was 0 cm, therefore these surveys were not in compliance with the "recent rainfall" criterion above. The average high temperature between 25 August through 16 September was 33.6 ^{o}C (92.4 ^{o}F), the average low was 23.8 ^{o}C (74.8^{o} F), and the total rainfall was 21.1 cm, so the "recent rainfall" criterion was satisfied for these surveys.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1, Figure 2 and Figure 3), therefore the fourth climate criterion is satisfied for surveys conducted at this site.

281-080
Surveys for feature 281-080 were conducted on 16 and 24 September and on 1 October 2010. The average high temperature between 9 September and 1 October was 31.3^{o} C (88.3 ^{o}F), the average low was 21.5^{o} C (70.7^{o} F), and the total rainfall was 1.8 cm. The total rainfall of 1.8 cm during the survey period is lower than the normal average rainfall for September, but was preceded by heavy rains on 7 and 8 September, and the total rainfall for the month (13.32 cm) was above average and well within the record precipitation ranges presented in Table 2, therefore these surveys satisfy the "recent rainfall" criterion above.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1), therefore the fourth climate criterion is satisfied for surveys conducted at this site.

281-083
Surveys for feature 281-083 were conducted on 14, 21 and 29 June and on 9 and 16 September 2010. The average high temperature between 7 June and 29 June was 33.8 ^{o}C (92.8 ^{o}F), the average low was 24.7 ^{o}C (76.5^{o} F), and the total rainfall was 0 cm, therefore these surveys did not meet the "recent rainfall" criterion above. The average high temperature between 2 September and 16 September was 32.6 ^{o}C (90.6 ^{o}F), the average low was 23.6 ^{o}C (74.4^{o} F), and the total rainfall was 20.9 cm, therefore these surveys satisfied the "recent rainfall" criterion above.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1 and Figure 3), therefore the fourth climate criterion is satisfied for surveys conducted at this site.

281-085 and 281-088
Surveys for features 281-085 and 281-088 were conducted on 25 June and on 1, 9 and 16 September 2010. The average high temperature between 18 June and 25 June was 34.2 ^{o}C (93.6 ^{o}F), the average low was 24.9 ^{o}C (76.8^{o} F), and the total rainfall was 0 cm, therefore these surveys did not meet the "recent rainfall" criterion above. The average high temperature between 25 August and 16 September was 33.6 ^{o}C (92.4 ^{o}F), the average low was 23.8 ^{o}C (74.8^{o} F), and the total rainfall was 21.1 cm, therefore these surveys satisfied the "recent rainfall" criterion above.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1 and Figure 3), therefore the fourth climate criterion is satisfied for surveys conducted at this site.

281-090
Surveys for feature 281-090 were conducted on 1, 9 and 16 September 2010. The average high temperature between 25 August and 16 September was 33.6^{o} C (92.4 ^{o}F), the average low was 23.8 C (74.8^{o} F), and the total rainfall was 21.1 cm, therefore these surveys satisfied the "recent rainfall" criterion above.

The US Drought Monitor website (http://drought.unl.edu/dm/monitor.html) indicates that the survey area was not under any abnormally dry or drought conditions during the monitoring period (Figure 1 and Figure 3), therefore the fourth climate criterion is satisfied for surveys conducted at this site.

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DRAFT KARST INVERTEBRATE TECHNICAL REPORT FOR US 281 FROM LOOP 1604 TO BORGFELD ROAD, BEXAR COUNTY, TEXAS

APPENDIX I

PERSONNEL

Personnel

Peter Sprouse served as the project manager on this investigation. Peter has been involved in cave and karst investigations since 1970, and has nine species named in his honor. He attended the University of Texas at Austin as a geology major, and since 1991 he has worked professionally in the fields of cave biology, land management, and cartography. He holds US Fish and Wildlife Service endangered species permit number TE014168-0 (covering endangered karst invertebrates in Texas) and Texas Dept. of Agriculture Pest Control License number 0362274. He has extensive experience in conducting karst surveys for invertebrate cave fauna habitat and biological inventories in caves and wells. He is a director of the Texas Speleological Survey and serves on the Balcones Canyonlands Preserve Scientific Advisory Committee Karst Subcommittee. The National Speleological Society has given him the prestigious Lew Bicking Award, named him an NSS Fellow, and he was the medal winner in the 1980 and 1986 NSS Cartographic Salons.

Krista McDermid served as principal biologist on this project. Krista holds a Master's degree in Wildlife Ecology from Texas State University in San Marcos, where she studied the Common Musk Turtle, *Sternotherus odoratus*. She also holds a bachelor's degree in Evolution, Ecology and Behavior from The University of Texas at Austin, where she worked on behavioral and genetic development of the zebra fish, *Danio rerio.* Krista has worked as a biologist for Texas Parks & Wildlife Department monitoring white-winged dove migration and population, and the City of Austin assisting with a mark-recapture study on the Jollyville Plateau Salamander, *Eurycea tonkawae*. Krista is a GIS technician; she received her certification in ArcView 3.x in 2005, and completed the postbaccalaureate certification program in geographic information systems through Penn State University in 2010. She has worked with Zara since 2007 and in that time has participated in numerous habitat surveys for listed karst invertebrates, cave fauna surveys, karst feature surveys, presence/absence surveys and biological monitoring for listed karst invertebrates. She has also conducted aquatic macro-invertebrate habitat and presence/absence surveys for aquifer species in Hays, Bexar, Uvalde and Medina Counties. She holds Texas Parks and Wildlife Scientific Research Permit SPR-0608-082 (expires 5 June 2011) to collect and study aquifer fauna and U.S. Fish and Wildlife Service Permit TE192229-0 (expires 30 October 2011) to collect and study federally listed endangered Texas karst invertebrate species.

Bill Larsen conducted karst surveys, excavations, and biological inventories on this project. Bill began exploring and studying caves in 1986 and has since discovered over 300 caves in central Texas. He began working as a karst technician in 1990, subcontracting to George Veni and Associates. In 2009 he became an employee of Zara Environmental. Much of his work has been in the San Antonio to Austin area and has included grid searches for karst features, excavation of caves and karst features, collection of invertebrate karst species for study, biomonitoring caves, and well sampling for fauna. Bill holds a USFWS Endangered Species Permit.

Jeanette Larsen conducted karst surveys, excavations, and biological inventories on this project. Jeanette has a Bachelor's degree in aquatic biology, with a minor in chemistry. She began studying caves in 1995. She has worked as a karst technician since 2000. Much of her work has been in the San Antonio to Austin area, and has included grid-searches for karst features, excavation of caves and karst features, collection of invertebrate karst species for study, and biomonitoring caves. She has also participated in several dye traces where she collected and analyzed samples. She holds USFWS Endangered Species Permit TE00294A-0.

Dr. Marcus O. Gary performed karst feature surveys on this project. He is a state of Texas licensed geologist (No. 10386) and hydrogeologist specializing in karst forming processes and the implications that karst geology has on natural resource management. Marcus received an Associate of Science degree in Marine Technology at the College of Oceaneering, a B.S. degree in hydrogeology and environmental geology at the University of Texas at Austin, and completed his doctorate at UT on a volcanogenic karst project in 2009. His research has been internationally recognized for investigating of the world's deepest underwater sinkhole and interpreting the geologic mechanisms that formed the karst system. For eight years he worked in the Texas Water Science Center of the U.S. Geological Survey, performing a multitude of tasks related to water resources. Projects included developing methods to quantify spring flow using acoustic technology, monitoring stage and water chemistry parameters at springs, performing a geochemical investigation of the Barton Springs Segment of the Edwards Aquifer, providing diving support for coring and karst monitoring projects, serving as a dive safety officer for the Central Region, and designing and implementing a variety of continuous monitoring projects at locations across Texas. His work at Zara since 2007 includes geologic assessments, drainage basin delineation, and dye tracing.

Kathleen O'Connor participated in karst feature surveys for this project. Kathleen has worked on Central Texas endangered species since 2004. She earned her M.S. in Wildlife Ecology from Texas State University in 2003, and subsequently worked as a Natural Resources Specialist at Travis County's Balcones Canyonlands Preserve. She has extensive experience working with Golden-cheeked warblers and Black-capped vireos, including presence/absence surveys and territory mapping. She has also conducted numerous surveys for karst invertebrate and salamander species. She holds a USFWS permit covering endangered karst invertebrates and birds.

Sarah J. "Saj" Zappitello participated in karst feature surveys for this project. She earned a B.S. in Hydrogeology and Environmental Geology from the University of Texas, where as a research assistant. While at UT she published on the isotopic constraints and research applications of isotope ratios in aquifer studies. After graduating, Saj worked as a technician for the USGS, then became a hydrogeologist with INTERA Inc. She is currently a hydrogeologist with Zara Environmental LLC where her projects include aquifer dye traces, hydrogeological studies, and karst feature surveys and assessments. In addition to her education and professional background, Saj gains valuable experience recreationally caving and volunteering for non-profit institutions like the Texas Cave Management Association and Proyecto Espeleológico Purificación. Previous efforts with these groups involved exploring and surveying new caves, searching for and mapping karst features, and leading beginner trips to expose the public to karst hydrogeology. She holds a USFWS endangered species permit (TE208531-0) covering geologic research in central Texas caves.

C. Clover Clamons contributed to this report. Clover received her Master of Science degree from Baylor University, where she studied soils and groundwater monitoring of seasonal wetlands on Galveston Island. Her work experience includes the preparation of NEPA biological and environmental assessments, as well as TCEQ geologic assessments. She previously served as a Senior Environmental Coordinator for the Lower Colorado River Authority, and a Water Resource Planner at the Barton Springs/Edwards Aquifer Conservation District.

Norman "Cass" Meyer contributed to this report. Cass is a geoscientist focusing on surface water movement and its interaction with groundwater migration. He earned a Bachelor of

Science in Geology from the University of Texas, where he worked as a laboratory technician in the Structural Geology department. Upon graduation, Cass worked for two years in the Austin office of Fugro Geotechnical Consultants, Inc., until spring 2010 when he began at Zara Environmental LLC. He conducts down-hole camera analysis of possible karst features. He also creates GIS maps and illustrations.

Paul Bryant participated in karst feature surveys and excavations on this project. Paul has had extensive experience in karst assessments and management since 1994. His project experience includes karst feature surveys, feature excavations, subterranean fauna surveys, groundwater tracing, and freshwater mussel surveys.

Charley Savvas participated in karst feature surveys on this project. He has conducted karst feature surveys, feature excavations, cave gate installations, and biological surveys in caves since 1989. He has extensive experience in karst investigations at Camp Bullis and Fort Hood, Texas, and has participated in scientific research expeditions to Belize, China, Guatemala, Madagascar, Mariana Islands, and Mexico as a volunteer.

Ellie Watson conducted feature excavations on this project. Ellie holds a Bachelor of Arts degree in Business Administration from John Brown University. She is experienced in conducting karst feature excavations and mapping of caves.

Tony Galvan conducted feature excavations on this project. Tony is experienced in conducting karst feature excavations for species habitat assessments.